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Best Demonstrated Available Technology (BDAT) Background Document for F006

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FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
BACKGROUND DOCUMENT FOR
F006

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EXECUTIVE SUMMARY

BDAT Treatment Standards for F006

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act as enacted by the Hazardous and Solid Waste Amendments on November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed waste identified in 40 CFR 261.31 as F006. Compliance with these BDAT treatment standards is a prerequisite for placement of the waste in units designated as land disposal units according to 40 CFR Part 268. The effective date of these treatment standards is August 8, 1988.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in F006 waste and for developing treatment standards for those regulated constituents. The document also provides waste characterization and treatment information that serves as a basis for determining whether variances may be warranted. EPA may grant a treatment variance in cases where the Agency determines that the waste in question is more difficult to treat than the waste upon which the BDAT treatment standards are based.

The introductory section, which appears verbatim in all the First Third background documents, summarizes the Agency's legal authority and promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the document presents waste-specific information: the number and locations of facilities affected by the land disposal restrictions for F006 waste, the waste-generating process, characterization data, the technologies used to treat the waste (or similar wastes), and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

F006 waste is listed in 40 CFR 261.31 as "wastewater treatment sludges from electroplating operations except from the following processes: (1) sulfuric acid anodizing of aluminum; (2) tin plating on carbon steel; (3) zinc plating (segregated basis) on carbon steel; (4) aluminum or zinc-aluminum plating on carbon steel; (5) cleaning/stripping associated with tin, zinc, and aluminum plating on carbon steel; and (6) chemical etching and milling of aluminum."

This listing includes wastewater treatment sludges from the following processes: (1) common and precious metals electroplating, except tin, zinc (segregated basis),[*] aluminum, and zinc-aluminum plating on carbon steel; (2) anodizing, except sulfuric acid anodizing of aluminum; (3) chemical etching and milling, except when performed on aluminum; and (4) cleaning and stripping, except when associated with tin, zinc, and aluminum plating on carbon steel (See 51 FR 43350). EPA has established a separate group of waste codes for spent cyanide electroplating baths and residues (F007, F008, and F009) and a separate waste code for the wastewater treatment sludges from the electroplating operation referred to as chemical conversion coating of aluminum (F019). EPA is currently studying these codes and will develop treatment standards for them based on these studies.

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[*] "Zinc plating (segregated basis)" refers to noncyanidic zinc plating processes. For example, wastewater treatment sludges from zinc plating using baths formulated from zinc oxide and/or sodium hydroxide would be excluded from the listing, while sludges from baths formulated from zinc cyanide and/or sodium cyanide would not be excluded. Where both cyanidic and noncyanidic baths are used, the exclusion applies to sludges from the noncyanidic processes as long as they are segregated from sludges that result from cyanidic plating processes.

EPA has estimated that 4,500 facilities are potential generators of F006 waste. Generators of F006 usually fall under Standard Industrial Classification (SIC) Code series 3000.

At this time treatment standards are only being established for F006 nonwastewaters; EPA intends to propose and promulgate treatment standards for F006 wastewaters by May 8, 1990. (For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition must comply with the treatment standards for nonwastewaters.) Regarding the status of F006 wastewaters prior to May 8, 1990, facilities are referred to Section III.C.3 of the preamble for the final First Third rule.

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*The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by method 209C (Total Suspended Solids Dried at 103-105°C) in Standard Methods for the Examination of Water and Wastewater, Sixteenth Edition.

For F006 nonwastewaters, the Agency is establishing treatment standards for cadmium, chromium, lead, nickel, and silver, which were found to leach at treatable levels from the untreated waste. The treatment standards are based on performance data from stabilization. The Agency is not regulating cyanide in F006 wastes at this time; however, EPA is presently collecting data on treatment of cyanide and expects to propose standards in the near future. EPA may also in the future develop regulations for other BDAT metals and organics depending on data and information that become known to the Agency regarding their presence in the untreated waste.

The following table presents the treatment standards for F006 nonwastewaters. These treatment standards reflect the concentration of constituents in the leachate from the Toxicity Characteristic Leaching Procedure (TCLP). The units for the leachate concentration are mg/l (parts per million on a weight-by-volume basis). If the concentrations of the regulated constituents in F006 waste, as generated, are lower than or equal to the proposed BDAT treatment standards, then treatment is not necessary as a prerequisite to land disposal.

Testing procedures are specifically identified in Appendix B of this background document.

BDAT Treatment Standards for F006

Constituent	Maximum for any single grab sample		
	Nonwastewater		Wastewater[a]
	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
Cadmium	NA	0.066	
Chromium	NA	5.2	
Lead	NA	0.51	
Nickel	NA	0.32	
Silver	NA	0.072	
Cyanide	Reserved	Reserved	

NA = Not applicable.

[a] EPA intends to propose and promulgate F006 wastewater treatment standards prior to May 8, 1990.

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the best demonstrated available technology (BDAT) treatment standards were developed, a summary of EPA's promulgated methodology for developing the BDAT treatment standards, and, finally, a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that satisfy such levels or methods of treatment established by EPA, i.e., treatment standards, are not prohibited from being land disposed.

In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters. Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, a particular constituent present in the wastes can be treated to the same concentration in all the wastes.

In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the amendments allow the Agency to grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set treatment standards by the statutory deadline for any hazardous waste in the First Third or Second Third waste groups (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets treatment standards for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set treatment standards for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvent and dioxin wastes by November 8, 1986;
2. The "California List" wastes by July 8, 1987;
3. At least one-third of all listed hazardous wastes by August 8, 1988 (First Third);

4. At least two-thirds of all listed hazardous wastes by June 8, 1989 (Second Third); and

5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish treatment standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third land disposal restriction rules. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m).

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than to require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that hazardous constituents in wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the wastes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one of the wastes in the group, the waste from which treatment standards are to be developed, is expected to be most difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are currently used on a full-scale basis to treat the waste of interest or a waste judged to be similar (see 51 FR 40588, November 7, 1986). EPA also will consider as demonstrated treatment those technologies used to separate or otherwise process chemicals and other materials on a full-scale basis. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. (The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document.) If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no full-scale treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste. Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also "available." To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste. These criteria are discussed below.

1. Commercially available treatment. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

2. Substantial treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern (provided the nondetectable levels are low relative to the concentrations in the untreated waste). If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

   - Number and types of constituents treated;
   - Performance (concentration of the constituents in the treatment residuals); and
   - Percent of constituents removed.

EPA will only set treatment standards based on a technology that meets both availability criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best demonstrated technology is unavailable, the treatment standards will be based on the next best demonstrated treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become available.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are considered in determining BDAT. The data evaluation includes data already collected directly by

EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (1) the identification of facilities for site visits, (2) the engineering site visit, (3) the sampling and analysis plan, (4) the sampling visit, and (5) the onsite engineering report.

(1) Identification of facilities for site visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities (TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using full-scale treatment systems. If performance data from properly designed and operated full-scale systems treating a particular waste or a waste judged to be similar are not available, EPA may use data from research facility operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering site visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to

ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and analysis plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific sampling and analysis plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency

of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific SAP within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of BDAT treatment standards. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up onsite engineering report.

(5) Onsite engineering report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the onsite engineering report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes that appear in Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986.

After the OER is completed, the report is submitted to the waste generator and/or treater for review. This review provides a final opportunity for claiming any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT list. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a

Table 1-1 BDAT Constituent List

BDAT reference no.	Constituent	CAS no.
	Volatile organics	
222.	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110-75-8
14.	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19.	Dibromomethane	74-95-3
20.	trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22.	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	trans-1,2-Dichloroethene	156-60-5
26.	1,2-Dichloropropane	78-87-5
27.	trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29.	1,4-Dioxane	123-91-1
224.	2-Ethoxyethanol	110-80-5
225.	Ethyl acetate	141-78-6
226.	Ethyl benzene	100-41-4
30.	Ethyl cyanide	107-12-0
227.	Ethyl ether	60-29-7
31.	Ethyl methacrylate	97-63-2
214.	Ethylene oxide	75-21-8
32.	Iodomethane	74-88-4
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78-93-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Volatile organics (continued)	
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoro-ethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4-Xylene	106-44-5
	Semivolatile organics	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	N-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-3
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics other than metals	
169.	Cyanide	57-12-5
170.	Fluoride	16964-48-8
171.	Sulfide	8496-25-8
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Organochlorine pesticides (continued)	
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202.	Aroclor 1232	11141-16-5
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") in March 1987. Additional constituents are added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. A waste can be listed as a toxic waste on the basis that it contains a constituent in Appendix VIII.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT constituent list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water, and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.

4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high performance liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is usually not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and the other inorganics, by using the same analytical methods.

(2) Constituent selection analysis. The constituents that the Agency selects for regulation in each waste are, in general, those found in the untreated wastes at treatable concentrations. For certain waste

codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to develop of list of potentially regulated constituents by summarizing all the constituents that are present or are likely to be present in the untreated waste at treatable concentrations. A constituent is considered present in a waste if the constituent (1) is detected in the untreated waste above the detection limit, (2) is detected in any of the treated residuals above the detection limit, or (3) is likely to be present based on the Agency's analyses of the waste-generating process. In case (2), the presence of other constituents in the untreated waste may interfere with the quantification of the constituent of concern, making the detection limit relatively high and resulting in a finding of "not detected" when, in fact, the constituent is present in the waste. Thus, the Agency reserves the right to regulate such constituents.

After developing a list of potential constituents for regulation. EPA reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents on the list. This indicator analysis is done for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6 of this background document.

(3) Calculation of standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average accuracy-corrected treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard for each constituent of concern is calculated by first averaging the mean performance value for each technology and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the technologies used as the basis for the BDAT treatment standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

Usually the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these numerical standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standards is prohibited, wastes that are generated in such a way as to naturally meet the standards can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal or that specify use of certain treatment methods, all established treatment standards are expressed as concentration levels.

EPA is using both the total constituent concentration and the concentration of the constituent in the TCLP extract of the treated waste as a measure of technology performance.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA is using this measurement because most technologies for treatment of organics destroy or remove organics compounds. Accordingly, the best measure of performance would be the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP extract value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals, and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP extract concentration as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is that it reduces the amount of metal in a waste by separating the metal for recovery; total constituent concentration in the treated residual, therefore, is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP extract concentration as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total and the TCLP extract constituent concentrations prior to land disposing the waste.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP value as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

BDAT for a waste must be the "best" of the demonstrated available technologies. EPA determines which technology constitutes "best" after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each demonstrated technology to that of the others. If only one technology is identified as demonstrated, it is considered "best"; if it is available, the technology is BDAT.

(1) Screening of treatment data. The first activity in determining which of the treatment technologies represent treatment by BDAT is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for the waste code(s) of interest are discussed in Section 3.2 of this document.)

2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the true value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP extract concentration for metals from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to use the data as a basis for the treatment standards. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern.

(2) Comparison of treatment data. In cases in which EPA has treatment data from more than one demonstrated available technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If EPA finds that one technology performs significantly better (i.e., is "best"), BDAT treatment standards

are the level of performance achieved by that best technology multiplied by the corresponding variability factor for each regulated constituent. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the technologies.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011.

To calculate the treatment standards for the land disposal restriction rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking--which is the addition of a known amount of the constituent--minus the initial concentration in the samples, all divided by the spike amount added) for each spiked sample of the treated residual. Once the recovery values are determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

2. If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (1) above.

3. If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spike sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by using the lowest average value.

4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is similar (e.g., if the data represent an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition methods, the specific procedures and equipment used are documented. In addition, any deviations from the SW-846, Third Edition methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from treatment trains generating multiple residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all derived-from wastes meeting the Agency definition of wastewater (less than 1 percent total organic carbon (TOC) and less than 1 percent total suspended solids) would have to meet the treatment standard for wastewaters. All residuals not meeting this definition would have to meet the treatment standard for nonwastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and other derived-from residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR 261.3(c)(2)(i)) or the mixture rule (40 CFR 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from managing listed wastes or that contain listed wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the listed hazardous waste as originally generated. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the original listed waste. Consequently, these residues are treated as the original listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain or from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology on the specific waste subject to the treatment standard. The Agency has determined that the constituents present in the untested waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance data for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries or processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether constituents in the untested wastes can be treated to the same level of performance as in the tested waste. First, EPA reviews the available waste characterization data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for the given waste(s) in Section 3.

Second, when analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste can be treated as well or better than the tested waste, the treatment standards can be transferred.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.
2. A statement of the petitioner's interest in the proposed action.
3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.
4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.
5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)
6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)
7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.
8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3 for a discussion of

waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.
10. A description of the methodologies and equipment used to obtain representative samples.
11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.
12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the Federal Register, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the Federal Register as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRIES AFFECTED AND WASTE CHARACTERIZATION

The purpose of this section is to describe the industry affected by the land disposal restrictions for F006, the electroplating processes generating the waste, and the available waste characterization data.

2.1 Industries Affected

The listed waste F006 is generated as the wastewater treatment sludges from the following processes: (1) common and precious metals electroplating, except tin, zinc (segregated basis),* aluminum, and zinc-aluminum plating on carbon steel; (2) anodizing, except sulfuric acid anodizing of aluminum; (3) chemical etching and milling, except when performed on aluminum; and (4) cleaning and stripping, except when associated with tin, zinc, and aluminum plating on carbon steel. Using the 1985 Biennial Report Data Base, EPA identified approximately 4,500 facilities as generators of F006 wastes. Figure 2-1 depicts the number of F006 generators by State, while Table 2-1 identifies the number

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*"Zinc plating (segregated basis)" refers to noncyanidic zinc plating processes. For example, wastewater treatment sludges from zinc plating using baths formulated from zinc oxide and/or sodium hydroxide would be excluded from the listing while sludges from baths formulated from zinc cyanide and/or sodium cyanide would not be excluded. Where both cyanidic and noncyanidic baths are used, the exclusion applies to sludges from the noncyanidic processes as long as they are segregated from sludges that result from cyanidic plating processes.

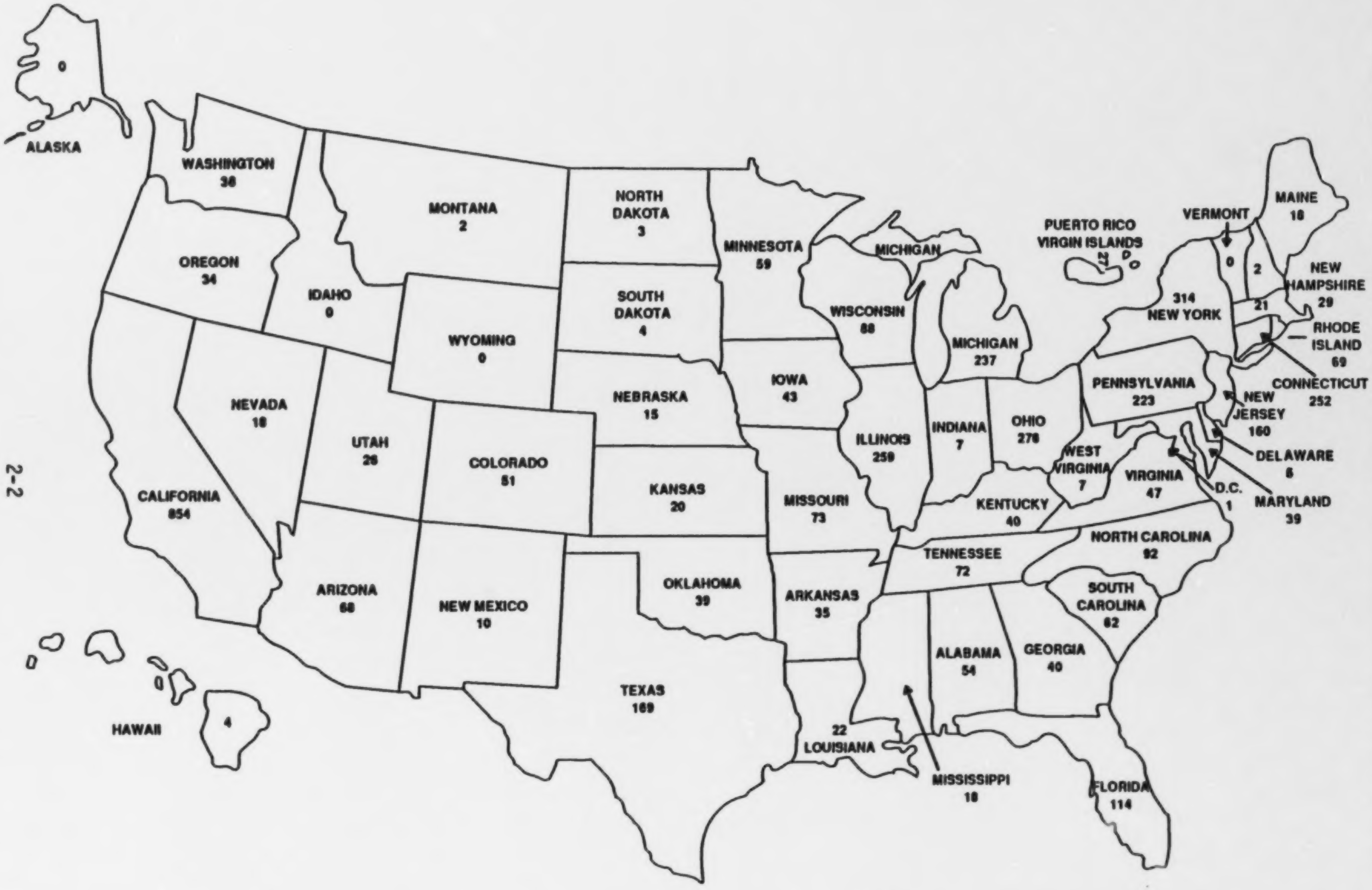
ALASKA
0
WASHINGTON
36
OREGON
34
CALIFORNIA
854
NEVADA
18
IDAHO
0
MONTANA
2
WYOMING
0
UTAH
26
COLORADO
51
ARIZONA
68
NEW MEXICO
10
NORTH DAKOTA
3
SOUTH DAKOTA
4
NEBRASKA
15
KANSAS
20
OKLAHOMA
39
TEXAS
169
MINNESOTA
59
IOWA
43
MISSOURI
73
ARKANSAS
35
LOUISIANA
22
WISCONSIN
88
MICHIGAN
MICHIGAN
237
ILLINOIS
259
INDIANA
7
OHIO
276
KENTUCKY
40
TENNESSEE
72
MISSISSIPPI
18
ALABAMA
54
GEORGIA
40
FLORIDA
114
SOUTH CAROLINA
62
NORTH CAROLINA
92
VIRGINIA
47
WEST VIRGINIA
7
PENNSYLVANIA
223
NEW YORK
314
PUERTO RICO
VIRGIN ISLANDS
27
VERMONT
0
2
NEW HAMPSHIRE
29
MAINE
18
21
RHODE ISLAND
69
CONNECTICUT
252
NEW JERSEY
160
DELAWARE
6
D.C.
1
MARYLAND
39
HAWAII
4

FIGURE 2-1 GEOGRAPHICAL DISTRIBUTION OF ELECTROPLATING FACILITIES GENERATING F006 WASTE

Table 2-1 Facilities Producing F006 Waste by State and Region

EPA Region	State	Number of facilities
I	Connecticut	252
	Maine	18
	Massachusetts	264
	New Hampshire	29
	Rhode Island	69
	Vermont	10
II	New York	314
	New Jersey	160
	Puerto Rico	27
	Virgin Islands	0
III	Delaware	5
	Pennsylvania	223
	Maryland	39
	Virginia	47
	West Virginia	7
	Washington, D.C.	1
IV	Alabama	54
	Georgia	40
	Florida	114
	Kentucky	40
	North Carolina	92
	Mississippi	18
	South Carolina	62
	Tennessee	72
V	Illinois	259
	Indiana	131
	Michigan	237
	Minnesota	59
	Ohio	276
	Wisconsin	88
VI	Arkansas	35
	Louisiana	22
	New Mexico	10
	Oklahoma	39
	Texas	169

Table 2-1 (Continued)

EPA Region	State	Number of facilities
VII	Iowa	43
	Kansas	20
	Missouri	73
	Nebraska	15
VIII	Colorado	51
	Montana	2
	North Dakota	3
	South Dakota	4
	Utah	26
	Wyoming	0
IX	California	854
	Arizona	68
	Nevada	18
X	Oregon	34
	Washington	38
	Hawaii	4
	Idaho	9
	Alaska	0
		4544

Source: USEPA 1988. F006 generators data extracted from 1985 Biennial Report data base computer run dated March 12. 1988.

of F006 generators by State and by Region. In the preamble for the Effluent Limitation Guidelines for the Metal Finishing Industry (40 CFR Part 413), the Agency identified 13,500 facilities in the electroplating/metal finishing industry that use 46 electroplating and metal finishing unit operations listed in 48 FR 32482. The 4,500 facilities generating F006 are a subset of the 13,500 facilities in the metal finishing industry.

Generators of F006 usually fall under Standard Industrial Classification (SIC) code series 3000 described as the fabricated metal products except machinery and transportation equipment; machinery except electrical; electrical and electronic machinery, equipment, and supplies; transportation equipment; measuring, analyzing, and controlling instruments; and miscellaneous manufacturing industries. EPA is currently compiling data and information on the amount of F006 generated and the quantities of F006 wastes land disposed. One source of information estimates that 1.4 million tons of F006 waste are generated in this country each year. The Agency estimates, on the basis of the recently compiled EPA Treatment, Storage, Disposal and Recovery Survey, that approximately 5 million tons of F006 waste are land disposed every year.

2.2 Process Description

The following subsections describe each of the four operations that EPA has determined generate F006. These operations are electroplating, anodizing, chemical etching and milling, and metal cleaning and stripping. Figure 2-2 presents a general schematic of an electroplating wastewater system and shows where F006 is generated.

2.2.1 Electroplating

Electroplating is the application of a thin surface coating of one metal upon another by electrodeposition. This surface coating is applied to provide corrosion protection, wear or erosion resistance, or antifrictional characteristics, or for decorative purposes. The electroplating of common metals includes the processes in which ferrous or nonferrous base material is electroplated with the following metals or metal alloys: copper, nickel, chromium, brass, bronze, zinc, tin, lead, cadmium, iron, aluminum, or combinations thereof. The alloy brass consists of copper and zinc; the alloy bronze consists of copper and tin. Precious metals electroplating include the processes in which a ferrous or nonferrous base material is plated with gold, silver, palladium, platinum, rhodium, indium, ruthenium, iridium, osmium, or combinations thereof.

In electroplating, metal ions in acid, alkaline, or neutral solutions are reduced on cathodic surfaces. The cathodic surfaces are the workpieces being plated. The metal ions in solution are usually replenished by the dissolution of metal from anodes or small pieces contained in inert wire or metal baskets. Replenishment with metal salts is also practiced, especially for chromium plating. In this case, an inert material must be selected for the anodes. Hundreds of different electroplating solutions have been adopted commercially, but only two or

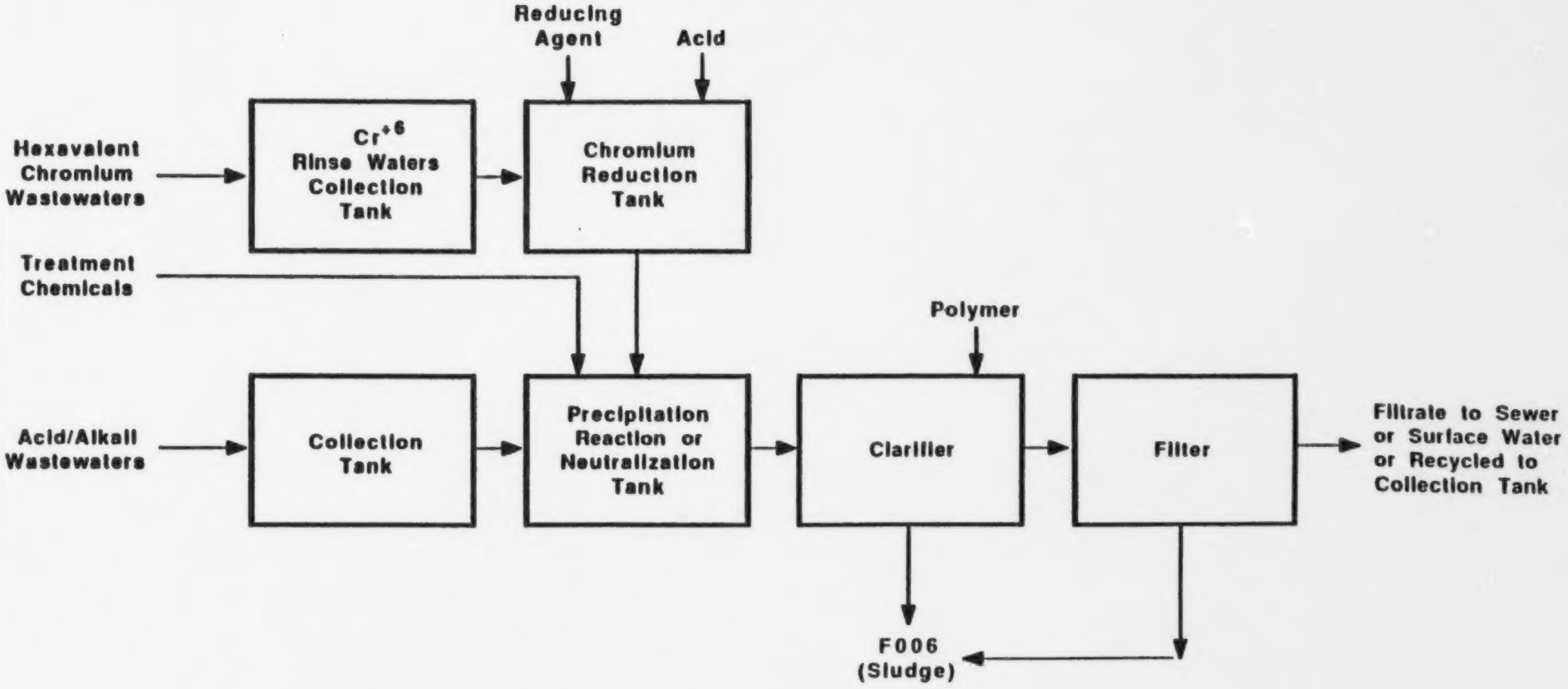
Reducing Agent
Acid
Hexavalent Chromium Wastewaters
Cr^{+6} Rinse Waters Collection Tank
Chromium Reduction Tank
Treatment Chemicals
Polymer
Acid/Alkali Wastewaters
Collection Tank
Precipitation Reaction or Neutralization Tank
Clarifier
Filter
Filtrate to Sewer or Surface Water or Recycled to Collection Tank
F006 (Sludge)

Figure 2-2 General Schematic of a Wastewater Treatment System

three types are used widely for a particular metal or alloy. For example, cyanide solutions are popular for copper, zinc, brass, cadmium, silver, and gold. However, noncyanide alkaline solutions containing pyrophosphate have come into use recently for zinc and copper. Acid sulfate solutions are used for plating zinc, copper, tin, and nickel, especially, relatively simple shapes. Cadmium and zinc are sometimes electroplated from neutral or slightly acidic chloride solutions.

Electroplating baths contain metals, metal salts, acids, alkalies, and various bath control compounds. All of these material contribute to the wastewater streams either through part dragout, batch dump, or floor spill. The sludge from spent plating baths also contains metals. Table 2-2 outlines some typical electroplating bath chemical compositions.

2.2.2 Anodizing

Anodizing is an electrolytic oxidation process that converts the surface of the metal to an oxide. These oxide coatings provide corrosion protection, decorative surfaces, a base for painting and other coating processes, and special electrical and mechanical properties. Aluminum is the most frequently anodized material, while some magnesium, stainless steel (electropolish), and limited amounts of zinc and titanium are also treated.

Although most of anodizing is carried out by the immersion of racked parts in tanks, continuous anodizing is done on large coils of aluminum performed in a manner similar to continuous electroplating. For aluminum parts, the formation of the oxide occurs when the parts are made anodic

Table 2-2 Typical Electroplating Baths and Their Chemical Composition

Plating compound	Constituents	Concentration (g/l)
Cadmium cyanide	Cadmium oxide	22.5
	Cadmium	19.5
	Sodium cyanide	77.9
	Sodium hydroxide	14.2
Cadmium fluoroborate	Cadmium fluoroborate	251.2
	Cadmium (as metal)	94.4
	Ammonium fluoroborate	59.9
	Boric acid	27.0
Chromium electroplate	Chromic acid	172.3
	Sulfate	1.3
	Fluoride	0.7
Copper cyanide	Copper cyanide	26.2
	Free sodium cyanide	5.6
	Sodium carbonate	37.4
	Rochelle salt	44.9
Gold cyanide	Gold (as potassium gold cyanide)	8
	Potassium cyanide	30
	Potassium carbonate	30
	Depotassium phosphate	30
Acid nickel	Nickel sulfate	330
	Nickel chloride	45
	Boric acid	37
Silver cyanide	Silver cyanide	35.9
	Potassium cyanide	59.9
	Potassium carbonate (min.)	15.0
	Metallic silver	23.8
	Free cyanide	41.2
Zinc cyanide	Zinc sulfate	374.5
	Sodium sulfate	71.5
	Magnesium sulfate	59.9

Reference: USEPA 1980b.

in dilute sulfuric acid or dilute chromic acid solutions. The oxide layer begins formation at the extreme outer surface, and as the reaction proceeds, the oxide grows into the metal. The oxide formed last, known as the boundary layer, is located at the interface between the base metal and oxide. The boundary is extremely thin and nonporous. Chromic acid anodic coatings are more protective than sulfuric acid coatings and have a relatively thick boundary layer. For these reasons, a chromic acid bath is used if a complete rinsing of the part cannot be achieved.

2.2.3 Chemical Etching and Milling

These processes are used to produce specific design configurations and tolerances or surface appearances on parts by controlled dissolution with chemical reagents or etchants. Included in this classification are the processes of chemical milling, chemical etching, and bright dipping. Chemical etching is the same process as chemical milling, but the rates and depths of metal removal are usually much greater in chemical milling. Typical solutions for chemical milling and etching include ferric chloride, nitric acid, ammonium persulfate, chromic acid, cupric chloride, hydrochloric acid, and combinations of these reagents. Bright dipping is a specialized form of etching that is used to remove oxide and tarnish from ferrous and nonferrous materials and is frequently performed just prior to plating. Bright dipping can produce a range of surface appearances from bright clean to brilliant depending on the surface smoothness desired for the finished part. Bright dipping solutions usually involve mixtures of two or more of these acids: sulfuric, chromic, phosphoric, nitric, and hydrochloric.

2.2.4 Metal Cleaning and Stripping

Metal cleaning and stripping operations are designed to prepare metal surfaces for electroplating. Cleaning activities involve a preliminary bath which may include solvent degreasing, emulsion cleaners, and/or alkali or acid cleaners. Following precleaning, metal parts are usually electrocleaned. This step typically employs an alkaline solution and cement to provide either anodic or cathodic cleaning. A third type of electrocleaning referred to as periodic reversal (PR) employs an alternating anodic/cathodic current to remove smut, oxide, and scale from ferrous metal parts. Cleaning baths eventually become contaminated with metals derived from the cleaned parts and result in generation of sludges that may be hazardous.

Metal stripping is the chemical removal of metal plating coatings from base metal products by immersion of the plated part in an aqueous bath of appropriate chemical composition. When a plated coating on a part does not meet product quality specifications, it may be more economical to remove the metal plating and replace the part rather than scrap the entire plated part. Stripping baths can contain strong alkaline solutions of cyanide salts (for instance to strip copper plating from steel parts) or strong acids. The stripping solution dissolves the plated coating, leaving the base metal essentially untouched.

2.3 Waste Characterization

All waste characterization data available to the Agency for the F006 waste are summarized below. The major constituents in the waste and their approximate concentrations are presented in Table 2-3. Table 2-4 presents the concentration of each BDAT list metal constituent and cyanide in the waste. The concentration of individual metals is dependent on the type of electroplating solutions used in the electroplating process.

The waste characterization data presented in this background document are solely for the F006 sludge generated following the treatment of electroplating wastewaters. The Agency wishes to emphasize that sludges generated from treatment of spent cyanide plating baths are also classified as F007, F008, or F009 under EPA's "derived from" rule (40 CFR 261.3(c)(2)(i)). An example is a spent nickel sludge generated from nickel cyanide plating solution (an F007 wastewater). This bath solution may be sent through cyanide destruction and metal hydroxide precipitation for nickel removal separate from other wastewaters. The precipitated residual would be F007.

Table 2-3 Major Constituents in F006 Waste

Constituent	Concentrations (%)
Solids (Consisting of metal precipitates, including the BDAT metals associated with a particular electroplating process, (usually hydroxides) and unreacted treatment chemicals (usually lime))	2-73
Water	24-98
Cyanide	0-.05
Total organic carbon	0.04-3.0
	100

Table 2-4 BDAT Constituent Composition for Untreated F006 Waste

Constituent	Concentration (ppm)						
	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7
Metals							
154. Antimony	NA	NA	<10	22.4	NA	-	-
155. Arsenic	-	NA	2 - 5	<0.4	<6.24	-	-
156. Barium	0.74 - 85.5	NA	20 - 45	28.8	9-57	-	-
157. Beryllium	NA	NA	<2	<0.1	<97.6	-	-
158. Cadmium	1.3 - 720	1,280 - 4,070	10 - 20	0.37-1.75	<11-1,320	ND-22,000	0.003-1,180
159. Total chromium	2 - 49,000	147 - 8,610	3,200 - 75,000	1,650-2,625	35-730	200-137,000	<0.002-290,000
160. Copper	1.4 - 27,400	345 - 28,100	90 - 775	1.87-135	<6-760	-	-
161. Lead	1.69 - 24,500	NA	85 - 134	184-305	<6-408	-	<0.001-13,900
162. Mercury	-	NA	<1	<0.2	<0.32	-	-
163. Nickel	234 - 23,700	1,330 - 26,000	7,300 -49,000	11.8-17		-	0.06-170,000
164. Selenium	-	NA	<10	<0.03	<19-<23	-	-
165. Silver	0.51 - 38.9	NA	<2	<0.6-<1.0	NA	-	-
166. Thallium	NA	NA	<10	<20	NA	-	-
167. Vanadium	-	-	-	1.26	NA	-	-
168. Zinc	8.86 - 90,200	611 - 41,200	68 - 3,700	2,510-3,687	<29-220	-	-
169. Cyanide, total	<0.1 - 506	84.1 - 226	<2	-	0.1-5.8 (0.1 free CN)	-	<0.025-1,970
169. Cyanide, amenable	<0.10 - 0.22	<1 - 153	<2	-	-	-	0.003-167
221. Hexavalent chromium	NA	NA	0.14-1.0	NA	0.25-25.4	NA	<0.001-910
Organics (ppb)							
Acetone	-	-	<120 - <130	-	-	-	-
Acrolein	-	-	NA	-	-	-	-
Acrylonitrile	-	-	NA	-	-	-	-
Benzene	-	-	NA	-	-	-	-
Bromodichloromethane	-	-	<4.9 - <5.2	-	-	-	-
Bromoform	-	-	<4.9 - <5.2	-	-	-	-
Bromomethane	-	-	<12 - <13	-	-	-	-

Table 2-4 (Continued)

Constituent	Concentration (ppm) Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7
Organic (continued)							
2-Butanone	-	-	<25 - <26	-	-	-	-
Carbon disulfide	-	-	<4.9 - <5.2	-	-	-	-
Carbon tetrachloride	-	-	<4.9 - <5.2	-	-	-	-
Chlorobenzene	-	-	<4.9 - <5.2	-	-	-	-
Chloroethane	-	-	<12 - <13	-	-	-	-
2-Chloroethyl vinyl ether	-	-	<4.9 - <5.2	-	-	-	-
Chloroform	-	-	<4.9 - <5.2	-	-	-	-
Chloromethane	-	-	<12 - <13	-	-	-	-
Cis-1,3-dichloropropene	-	-	<4.9 - <5.2	-	-	-	-
Dibromochloromethane	-	-	<4.9 - <5.2	-	-	-	-
1,1-Dichloroethane	-	-	<4.9 - <5.2	-	-	-	-
1,2-Dichloroethane	-	-	<4.9 - <5.2	-	-	-	-
1,1-Dichloroethylene	-	-	<4.9 - <5.2	-	-	-	-
1,2-Dichloropropane	-	-	<4.9 - <5.2	-	-	-	-
Ethylbenzene	-	-	<4.9 - <5.2	-	-	-	-
2-Hexanone	-	-	<25 - <26	-	-	-	-
Methylene chloride	-	-	<12 - <13	-	-	-	-
4-Methyl-2-pentanone	-	-	<25 - <26	-	-	-	-
Styrene	-	-	<4.9 - <5.2	-	-	-	-
1,1,2,2-Tetrachloroethane	-	-	<12 - <13	-	-	-	-
Tetrachlorethylene	-	-	<4.9 - <5.2	-	-	-	-
Toluene	-	-	<4.9 - <5.2	-	-	-	-
Trans-1,2-dichloroethylene	-	-	<4.9 - <5.2	-	-	-	-
Trans-1,3-dichloropropene	-	-	<4.9 - <5.2	-	-	-	-
Trichloroethylene	-	-	<4.9 - <5.2	-	-	-	-
Vinyl acetate	-	-	NA	-	-	-	-
Vinyl chloride	-	-	<12 - <13	-	-	-	-
Xylenes (total)	-	-	<4.9 <5.2	-	-	-	-

Table 2-4 (Continued)

Constituent	Concentration (ppm) Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7
Other Parameters							
Fluoride	-	-	-	268	-	-	-
Oil and grease (mg/g)	0.03 - 37.7	-	-	-	-	-	-
Moisture %	29.1 - 91.2	-	47.4 - 48.94	-	-	-	-
SP gravity (g/ml)			1.38 - 1.493	-	-	-	-
Acidity as $CaCo_3$ (mg/l)			1,412	-	-	-	-
Alkalinity as $CaCO_3$ (mg/l)		-	-	-	-	-	-
Sulfide	-	-	-	21	-	-	-
Total organic carbon	-	-	<5,800	-	-	-	-

NA = Not analyzed.

Source 1 - Table 1 from Chemical Waste Management Report Technical Note 87-117, September 22, 1987. The complete data set for this facility can be found in Appendix B.
Source 2 - MRI draft memo to Ed Abrams, EPA-OSW, dated November 5, 1987.
Source 3 - Onsite Engineering Analysis Report for Envirite Corp., December 19, 1986, Table 6-13.
Source 4 - Memo to Ron Turner from R.D. Grotelueschem, John Deere Company, dated January 15, 1988.
Source 5 - F006 Waste description from Environ Report, 1984.
Source 6 - Listing Document Table 2 data provided on a dry-weight basis.
Source 7 - Data extracted for Table 3 of Draft Report. Review of Delisting Petitions for California List wastes subject to Land Disposal Restrictions, Versar Inc., March 1986.

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

In the previous section, a discussion of the industry and process generating F006 waste and a major constituent analysis of this waste were presented. This section describes the applicable and demonstrated treatment technologies and performance data for treatment of F006 waste. The technologies that are considered applicable to the treatment of F006 waste are those that treat BDAT list metals by reducing their concentration and/or their leachability in the waste. Included in this section are discussions of those applicable treatment technologies that have been demonstrated (i.e., are used on a full-scale basis for treatment of F006 waste). As shown in the previous section, F006 waste is principally composed of water, precipitated metals including BDAT list metals, other solids, cyanides, and low concentrations of volatile and semivolatile organics. The individual organic constituents present in F006 waste are measured at parts per billion levels. These concentrations are not believed to be treatable.

3.1 Applicable Treatment Technologies

EPA has identified three technologies as potentially applicable for treatment of F006--stabilization, vitrification, and metals recovery. The first two technologies are designed to reduce the leachability of the metals; the third reduces both the total concentration and the leachability of the metals.

Stabilization chemically reduces the mobility of hazardous metal constituents in a waste. Stabilizing agents, binders, and chemicals are added to a waste to minimize the quantities of metals that leach when the waste is in contact with water. Commonly used stabilization agents include portland cement, lime/pozzolan-based material, and cement kiln dust. Stabilization is described in Section 3.3.

Vitrification has also been identified by the Agency as an applicable technology. A vitrification process is used to immobilize hazardous constituents in the F006 waste to produce a vitrous or glass-like mass. Available performance data for this technology can be found in Section 4.

EPA has also identified high temperature metal recovery technologies as applicable. All high temperature metal recovery technologies act to reduce the concentration of metal in the waste through volatilization and recovery.

3.2 Other Treatment Technologies to Reduce the Generation of F006

A number of treatment technologies are available to reduce the amount of F006 that is initially generated or to generate F006 in such a manner that the leachability of constituents in it is reduced. EPA will be examining such technologies as part of its work in developing treatment standards for "D" wastes in the Final Third waste group. A brief discussion of many of these discussions can be found in EPA's Development Document for Effluent Limitations Guidelines and Standards for the Metal Finishing Point Source Category.

3.3 Demonstrated Treatment Technologies

Available information shows that all of the applicable technologies are demonstrated. Stabilization is used by at least ten facilities to treat F006 wastes. EPA knows of two full-scale facilities that use metals recovery for F006 wastes and one full-scale facility that treats F006 waste by vitrification. Below are detailed discussions of stabilization and high temperature metal recovery.

3.3.1 Stabilization of Metals

Stabilization refers to a broad class of treatment processes that chemically reduce the mobility of hazardous constituents in a waste. Solidification and fixation are other terms that are sometimes used synonymously with stabilization or to describe specific variations within the broader class of stabilization. Related technologies are encapsulation and thermoplastic binding; however, EPA considers these technologies to be distinct from stabilization in that the operational principles are significantly different.

(1) Applicability and use of stabilization. Stabilization is used when a waste contains metals that will leach from the waste when it is contacted by water. In general, this technology is applicable to wastes containing BDAT list metals and having a high filterable solids content, low total organic carbon content, and low oil and grease content. This technology is commonly used to treat residuals generated from treatment of electroplating wastewaters. For some wastes, an alternative to stabilization is metal recovery.

(2) Underlying principles of operation. The basic principle underlying this technology is that stabilizing agents and other chemicals are added to a waste to minimize the amount of metal that leaches. The

reduced leachability is accomplished by the formation of a lattice structure and/or chemical bonds that bind the metals to the solid matrix and thereby limit the amount of metal constituents that can be leached when water or a mild acid solution comes into contact with the waste material.

There are two principal stabilization processes used--cement-based and lime-based. A brief discussion of each is provided below. In both cement-based or lime/pozzolan-based techniques, the stabilizing process can be modified through the use of additives, such as silicates, that control curing rates or enhance the properties of the solid material.

(a) Portland cement-based process. Portland cement is a mixture of powdered oxides of calcium, silica, aluminum, and iron, produced by kiln burning of materials rich in calcium and silica at high temperatures (i.e., 1400°C/2550°F to 1500°C/2730°F). When the anhydrous cement powder is mixed with water, hydration occurs and the cement begins to set. The chemistry involved is complex because many different reactions occur depending on the composition of the cement mixture.

As the cement begins to set, a colloidal gel of indefinite composition and structure is formed. Over a period of time, the gel swells and forms a matrix composed of interlacing, thin, densely packed silicate fibrils. Constituents present in the waste slurry (e.g., hydroxides and carbonates of various heavy metals) are incorporated into the interstices of the cement matrix. The high pH of the cement mixture tends to keep metals in the form of insoluble hydroxide and carbonate salts. It has been hypothesized that metal ions may also be incorporated into the crystal structure of the cement matrix, but this hypothesis has not been verified.

(b) Lime/pozzolan-based process. Pozzolan, which contains finely divided, noncrystalline silica (e.g., fly ash or components of cement kiln dust) is a material that is not cementitious in itself but becomes so upon the addition of lime. Metals in the waste are converted to silicates or hydroxides, which inhibit leaching. Additives, again, can be used to reduce permeability and thereby further decrease leaching potential.

(c) Cement kiln dust process. A standard cement kiln dust (CKD) method is used for liquid wastes that do not pass the paint filter test (PFT) as received. Table 3-1 gives cement kiln dust composition data for the type of dust used for the stabilization of F006 waste. When cement kiln dust is used with liquid wastes, the mix ratio of 1 is common; for solid wastes, the mix ratio is typically 0.2 to 0.5. If the water content is high, then the higher mix ratio of 1.5 appears to be adequate. Typically, the mixture is cured at 38°C/100°F to stimulate the temperature rise for 24 hours. No additional additives or fixative agents are necessary; at times, water may be added to the mixture to aid in mixing the waste and stabilizing agent (in this case, cement kiln dust) and to maximize utilization of the reagent.

Table 3-1 Cement Kiln Dust Composition Data

	Concentration (mg/l)		
Constituent	Total composition	TCLP	Other characteristics
BDAT Metals			
Arsenic	38	<0.01	
Barium	92.7	2.74	
Cadmium	3.14	<0.01	
Chromium (total)	31.9	0.05	
Copper	44.8	0.16	
Lead	156	0.29	
Mercury	<0.033	<0.001	
Nickel	12.6	0.02	
Selenium	8.67	0.03	
Silver	4.13	0.02	
Zinc	65.6	0.04	
Other Metals			
Aluminum	31,000	NA	
Iron (total)	15,200	NA	
Magnesium	3,790	NA	
Other Non-BDAT Constituents			
Sodium	2300	NA	
Potassium	33,100	NA	
Calcium	41,900	NA	
Total sulfide (ppm)			<8
Ash content (%)			99.8
Total residue (@ 105°c)%			100
Alkalinity (as CaO %)			56.16
pH (10% solution)			12.55

NA = Not available

Reference:: Special waste analysis report dated June 15, 1987. Provided by Chemical Waste Management (Technical Center). (See Administrative Record for F006).

(3) Description of stabilization processes. In most stabilization processes, the waste, stabilizing agent, and other additives, if used, are mixed and then pumped to a curing vessel or area and allowed to cure. The actual operation (equipment requirements and process sequencing) will depend on several factors such as the nature of the waste, the quantity of the waste, the location of the waste in relation to the disposal site, the particular stabilization formulation to be used, and the curing rate. After curing, the solid formed is recovered from the processing equipment and shipped for final disposal.

In instances where waste contained in a lagoon is to be treated, the material should be first transferred to mixing vessels where stabilizing agents are added. The mixed material is then fed to a curing pad or vessel. After curing, the solid formed is removed for disposal. Equipment commonly used also includes facilities to store waste and chemical additives. Pumps can be used to transfer liquid or light sludge wastes to the mixing pits and pumpable uncured wastes to the curing site. Stabilized wastes are then removed to a final disposal site.

Commercial concrete mixing and handling equipment generally can be used with wastes. Weighing conveyors, metering cement hoppers, and mixers similar to concrete batching plants have been adapted in some operations. Where extremely dangerous materials are being treated, remote-control and in-drum mixing equipment, such as that used with nuclear waste, can be employed.

(4) Waste characteristics affecting performance. In determining whether stabilization is likely to achieve the same level of performance

on an untested waste as on a previously tested waste, the Agency will focus on the characteristics that inhibit the formation of either the chemical bonds or the lattice structure. The four characteristics EPA has identified as affecting treatment performance are the presence of (1) other metals and their concentrations, (2) fine particulates, (3) oil and grease, (4) organic compounds, and (5) sulfates and chloride concentrations.

(a) Other metals and their concentrations. When a waste contains a mixture of metals, it may not be possible to chemically stabilize the waste in a manner that optimizes the reduction in leachability for all constituents. The extent to which synergistic effects impact performance will depend on the type and concentration of other metals in the waste. The individual metals present and their concentrations can be measured by EPA Method 6010.

(b) Fine particulates. For both cement-based and lime/pozzolan-based processes, the literature states that very fine solid materials (i.e., those that pass through a No. 200 mesh sieve, 74-um particle size) can weaken the bonding between waste particles and cement by coating the particles. This coating can inhibit chemical bond formation and decrease the resistance of the material to leaching.

(c) Oil and grease. The presence of oil and grease in both cement-based and lime/pozzolan-based systems results in the coating of waste particles and the weakening of the bonding between the particle and the stabilizing agent. This coating can inhibit chemical bond formation, thereby decreasing the resistance of the material to leaching.

(d) Organic compounds. The presence of organic compounds in the waste interferes with the chemical reactions and bond formation, which inhibits curing of the stabilized material. This results in a stabilized waste having decreased resistance to leaching.

(e) Sulfate and chlorides. The presence of certain inorganic compounds will interfere with the chemical reactions, weakening bond strength and prolonging setting and curing time. Sulfate and chloride compounds may reduce the dimensional stability of the cured matrix, thereby increasing leachability potential.

Accordingly, EPA will examine these constituents when making decisions regarding transfer of treatment standards based on stabilization.

(5) Design and operating parameters. In designing a stabilization system, the principal parameters that should be optimized so that the amount of leachable metal constituents is minimized are (1) selection of stabilizing agents and other additives, (2) ratio of waste to stabilizing agents and other additives, (3) degree of mixing, and (4) curing conditions.

(a) Selection of stabilizing agents and other additives. The stabilizing agent and additives used will determine the chemistry and structure of the stabilized material and, therefore, will affect the leachability of the solid material. Stabilizing agents and additives must be carefully selected based on the chemical and physical characteristics of the waste to be stabilized. For example, the amount of sulfates in a waste must be considered when a choice is being made between a lime/pozzolan-based system and a portland cement-based system.

To select the type of stabilizing agents and additives, the waste should be tested in the laboratory with a variety of materials to determine the best combination.

(b) Amount of stabilizing agents and other additives. The amount of stabilizing agents and other additives is a critical parameter in that sufficient stabilizing materials are necessary in the mixture to bind the waste constituents of concern properly, thereby making them less susceptible to leaching. The appropriate weight ratios of waste to stabilizing agent and other additives are established empirically by setting up a series of laboratory tests that allow separate leachate testing of different mix ratios. The ratio of water to stabilizing agent (including water in waste) will also impact the strength and leaching characteristics of the stabilized material. Too much water will cause low strength; too little will make mixing difficult and, more importantly, may not allow the chemical reactions that bind the hazardous constituents to be fully completed.

(c) Mixing. The conditions of mixing include the type and duration of mixing. Mixing is necessary to ensure homogeneous distribution of the waste and the stabilizing agents. Both undermixing and overmixing are undesirable. The first condition results in a nonhomogeneous mixture; therefore, areas will exist within the waste where waste particles are neither chemically bonded to the stabilizing agent nor physically held within the lattice structure. Overmixing, on the other hand, may inhibit gel formation and ion adsorption in some stabilization systems. As with the relative amounts of waste, stabilizing agent, and additives within the system, optimal mixing conditions generally are determined through laboratory tests. During treatment it is important to monitor the degree (i.e., type and duration) of mixing to ensure that it reflects design conditions.

(d) Curing conditions. The curing conditions include the duration of curing and the ambient curing conditions (temperature and humidity). The duration of curing is a critical parameter to ensure that the waste particles have had sufficient time in which to form stable chemical bonds and/or lattice structures. The time necessary for complete stabilization depends upon the waste type and the stabilization used. The performance of the stabilized waste (i.e., the levels of constituents in the leachate) will be highly dependent upon whether complete stabilization has occurred. Higher temperatures and lower humidity increase the rate of curing by increasing the rate of evaporation of water from the solidification mixtures. However, if temperatures are too high, the evaporation rate can be excessive, resulting in too little water being available for completion of the stabilization reaction. The duration of the curing process, which should also be determined during the design stage, typically will be between 7 and 28 days.

3.3.2 High Temperature Metals Recovery

High temperature metals recovery (HTMR) provides for recovery of metals from wastes primarily by volatilization and collection. The process yields a metal product or products for reuse and reduces the concentration of metals in the residual. This process also significantly reduces the amount of treated waste that needs to be land disposed.

There are a number of different types of high temperature metal recovery systems; these systems generally differ from one another relative to the source of energy and the method of recovery. Such HTMR systems include the rotary kiln process, plasma arc reactor, rotary hearth/electric furnace system, molten slag reactor, and flame reactor. This technology is different from retorting in that HTMR is conducted in a carbon-reducing atmosphere while the retorting process simply vaporizes the untreated metal.

(1) Applicability and use of high temperature metals recovery. This process is applicable to wastes containing BDAT list metals with low water content (or a water content that can either be blended to the required level or lowered by dewatering) and low concentration of organics. The technology is applicable to a wide range of metal salts including cadmium, chromium, lead, mercury, nickel, and zinc.

This process is usually not used for mercury-containing wastes even though mercury will volatilize readily at the process temperatures present in high temperature units. The rotary kiln recovery process is one example of the technology, and it has been applied to zinc-bearing wastes as an upgrading step that yields a zinc oxide product for further refinement and subsequent reuse. Although this technology was originally developed in the 1920s for upgrading zinc from ores, it has recently been applied to electric furnace dust from the steel-making industry.

(2) Underlying principles of operation. The basic principle of operation for this technology is that metals are separated from a waste through volatilization in a reducing atmosphere where carbon is the reducing compound. An example chemical reaction would be:

$$2ZnO + C \rightarrow 2Zn + CO_2$$

In some cases, the waste contains not only BDAT list metal constituents that can be volatilized but also nonvolatile BDAT list metals. In such cases, the HTMR process can yield two recoverable product streams. Whether such recovery can be accomplished, however, depends on the type and concentration of metals in the original wastestream. Below is a discussion of the recovery techniques for the volatile stream, as well as for the waste material that is not volatilized.

(a) Recovery of volatilized metals. The volatilized metals can be recovered in the metallic form or as an oxide. Recovery is accomplished in the case of the metallic form by condensation alone and in the case of the oxide by reoxidation, condensation, and subsequent collection of the metal oxide particulates in a baghouse. There is no difference between these two types of metal product recovery systems relative to the kinds of waste that can be treated; the difference is in a facility's preference relative to product purity. In the former case, the direct condensation of metals, while more costly, allows for the separation and collection of metals in a relatively uncontaminated form; in the latter case, the metals are collected as a combination of several metal oxides. If necessary, this combination of metal oxides could be further processed to produce individual metal products of increased purity.

(b) Less volatile treatment residuals. The fraction of the waste that is not originally volatilized has three possible dispositions: (1) the material is such that it can be used directly as a product (e.g., a waste residual containing mostly metallic iron can be reused directly in steelmaking); (2) the material can be reused after further processing (e.g., a waste residual containing oxides of iron, chromium, and nickel can be reduced to the metallic form and then recovered for use in the manufacture of stainless steel); and (3) the material has no recoverable value and is land disposed as a slag.

(3) Description of high temperature metals recovery process. The process essentially consists of four operations: (1) a blending operation to control feed parameters, (2) high temperature processing, (3) a product collection system, and (4) handling of the less volatile treated residuals. A generic schematic diagram for high temperature metals recovery is shown in Figure 3-2.

(a) Blending operation. For the system shown, variations in feeds are minimized by blending wastes from different sources. Prior to

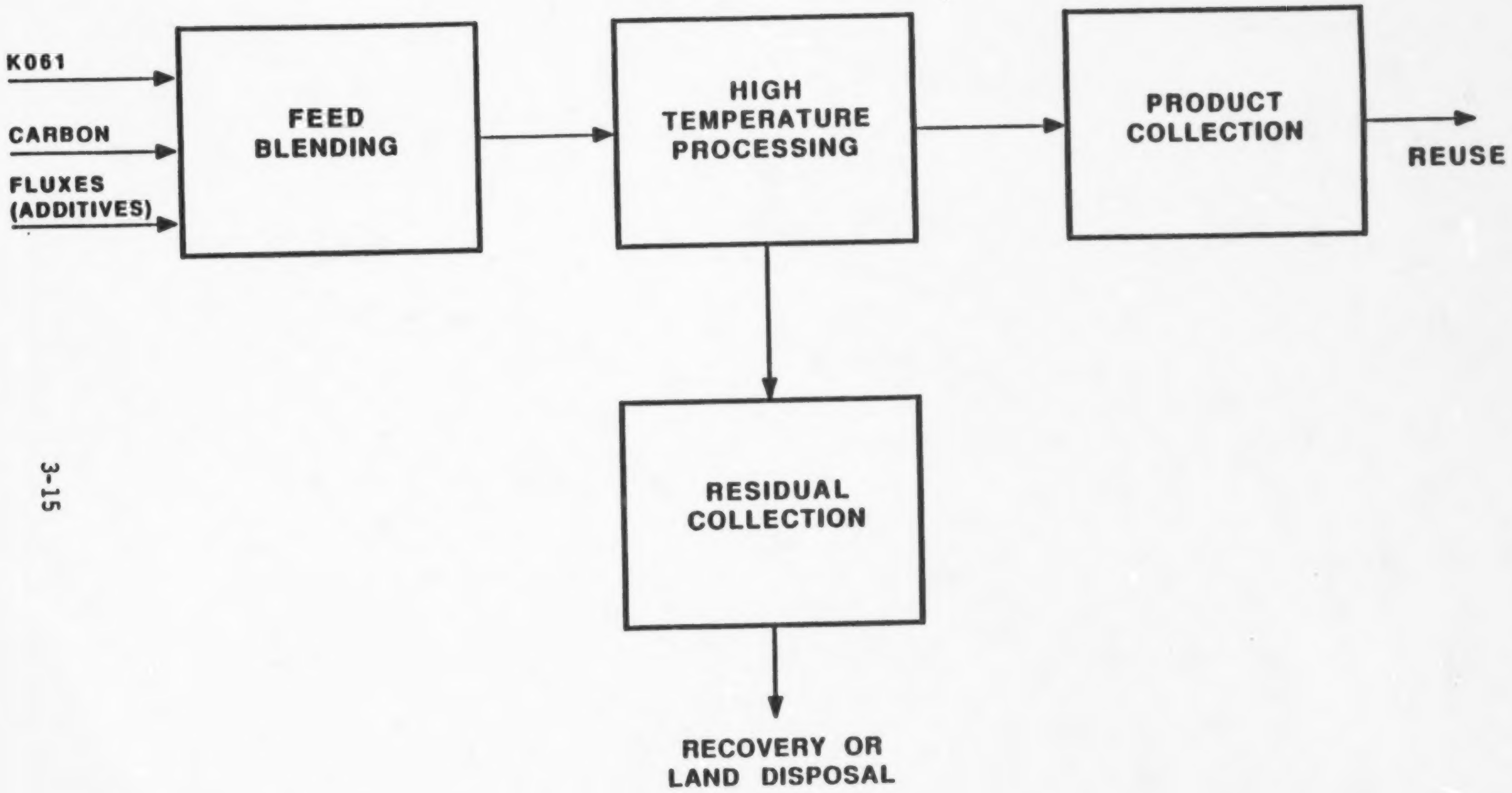
K061
CARBON
FLUXES (ADDITIVES)
FEED BLENDING
HIGH TEMPERATURE PROCESSING
PRODUCT COLLECTION
REUSE
RESIDUAL COLLECTION
RECOVERY OR LAND DISPOSAL

FIGURE 3-1 EXAMPLE HIGH TEMPERATURE METALS RECOVERY SYSTEM

feeding the kiln, fluxing agents are added to the waste. Carbon is also added to the waste as required. The fluxes (limestone or sand) are added to react with certain waste components, preventing their volatilization, thus improving the purity of the desired metals recovered. In addition, the moisture content is adjusted by either adding water or blending various wastes.

(b) High temperature processing. These materials are fed to the furnace, where they are heated and the chemical reactions take place. The combination of residence time and turbulence helps ensure maximum volatilization of metal constituents.

(c) Product collection. As discussed previously, the product collection system can consist of either a condenser or a combination condenser and baghouse. As noted earlier, the particular system depends on whether the metal is to be collected in the metallic form or as an oxide.

(d) Handling of less volatile treatment residuals. The equipment needed to handle the less volatile metal treated residuals depends on the final disposition of the material. If further recovery were performed, then the waste would be treated in another furnace. If the material were to be land disposed, the final process step would generally consist of quenching.

(4) Waste characteristics affecting performance In determining whether high temperature metals recovery technologies are likely to achieve the same level of performance on an untested waste as on a

previously tested waste, EPA will examine the following three waste characteristics that have an impact on treatability: (1) type and concentrations of metals in the waste, (2) relative volatility of the metals, and (3) heat transfer characteristics of the waste.

(a) Type and concentrations of metals in the waste. Because this is a metals recovery process, the product must meet certain requirements for recovery. If the waste contains other volatile metals that are difficult to separate and whose presence may affect the ability to refine the product for subsequent reuse, high temperature metals recovery may provide less effective treatment. Analytical methods for metals can be found in SW-846.

(b) Relative volatility. The relative volatilities of the metals in the waste also affect the ability to separate various metals. There is no conventional measurement technique for determining the relative volatility of a particular constituent in a given waste. EPA believes that the best measure of volatility of a specific metal constituent is the boiling point. EPA recognizes that the boiling point has certain shortcomings, primarily the fact that although boiling points are given for pure components, the other constituents in the waste will affect partial pressures and, thus, will affect the boiling point of the mixture. EPA has not identified a parameter that can better assess relative volatility. Boiling points of metals can be determined from the literature.

(c) Heat transfer characteristics. The ability to heat constituents within a waste matrix is a function of the heat transfer characteristics of a heterogeneous waste material. To be volatilized and recovered, the constituents being recovered from the waste must be heated near or above their boiling points. Whether sufficient heat will be transferred to the particular constituent to cause the metal to volatilize will depend on the heat transfer characteristics of a waste. There is no conventional direct measurement of the heat transfer characteristics of a waste. EPA believes that the best measure of heat transfer characteristics of the waste is thermal conductivity. The analytical method that EPA has identified for measurement of thermal conductivity is named "Guarded, Comparative, Longitudinal Heat Flow Technique"; it is described in Appendix D.

(5) Design and operating parameters The parameters that EPA will evaluate when determining whether a high temperature metals recovery system is well designed and well operated are (1) the furnace temperature, (2) the furnace residence time, (3) the amount and ratio of the feed blending materials, and (4) mixing. Below is an explanation of why EPA believes these parameters are important to an analysis of the design and operation of the system.

(a) Furnace temperature. For sufficient heat to be transferred to the waste for volatilization, high temperatures must be provided. The higher the temperature in the furnace, the more likely the constituents are to react with carbon to form free metals and volatilize. The temperature must be approximately equal to or greater than the boiling point of the metals being volatilized. Excessive temperatures could volatilize unwanted metals into the product, possibly inhibiting the potential for reuse of the volatilized product. In assessing performance during the treatment period, EPA would want continuous temperature data.

(b) Furnace residence time. Furnaces must be designed to ensure that the waste has sufficient time to be heated to the boiling point of the metals to be volatilized. The time necessary for complete volatilization of these constituents is dependent on the furnace temperature and the heat transfer characteristics of the waste. The residence time is a function of the physical dimensions of the furnace (length, diameter, and slope (for rotary kilns)), the rate of rotation (if applicable), and the feed rate.

(c) Amount and ratio of feed blending materials. For the maximum volatilization of the metals being recovered, the following feed parameters must be controlled by the addition of carbon, fluxes, and other agents if necessary; blending of these feed components is also needed to adjust the following feed parameters to the required volume: carbon content, moisture content, calcium-to-silica ratio, and initial concentration of the metals to be recovered. These parameters all affect the rate of the reduction reaction and volatilization. EPA will examine blending ratios during treatment to ensure that they comply with design conditions.

(d) Mixing. Effective mixing of the total components is necessary to ensure that a uniform waste is being treated. Turbulence in the furnace also ensures that no "pockets" of waste go untreated. Accordingly, EPA will examine the type and degree of mixing involved when assessing treatment design and performance.

4. PERFORMANCE DATA BASE

This section discusses all available performance data that EPA has on the demonstrated technologies discussed in Section 3 (stabilization, high temperature metals recovery, and vitrification). Performance data include the untreated and treated waste concentrations for a given constituent, the operating values that existed at the time the waste was being treated, the design values for the treatment technology, and data on waste characteristics that affect treatment performance. EPA has provided all such data to the extent that they are available in tables found at the end of this section.

EPA's use of these data in determining the technology that represents BDAT, and in the development of treatment standards, is discussed in Sections 5 and 7, respectively.

4.1 Stabilization Data

The stabilization data that the Agency has evaluated in the development of treatment standards for F006 are discussed below. EPA is presenting some of these data in this document; other data on stabilization of F006, evaluated but not used in the development of the treatment standards, can be found in the Administrative Record for this rulemaking.

The stabilization data that the Agency evaluated, but did not use in the development of the treatment standards for F006 were for the most part insufficient to assess treatment effectiveness. Specifically, the Agency did not have sufficient data on the binder-to-waste ratios to assess dilution effects, or data on the untreated leachate values were insufficient to determine whether treatment had occurred. These data consist primarily of EPA delisting petition data and data submitted in response to the California List "Notice of Availability" and the First Third rule. As noted above, all these data can be found in the Administrative Record for this rulemaking.

The data that EPA is using for the development of treatment standards for F006 are shown in Table 4-1. These data consist of a total of 209 treated data points for 11 metals. Nine of the 10 separate wastes are stabilized using two distinct binder-to-waste ratios; the other waste is stabilized using one binder-to-waste ratio. These data were submitted to EPA by a member of the waste management industry. The data represent wastes from a range of electroplating industries including automotive part manufacturing, aircraft overhauling, zinc plating, small engine manufacturing, circuit board manufacturing, and four wastes identified as F006 but not specifically characterized. A discussion of how EPA used these data in the development of the BDAT treatment standards can be found in Sections 5, 6, and 7.

4.2 High Temperature Metals Recovery

For high temperature metals recovery, EPA has untreated and treated waste data that include F006 wastes; however, the available data cannot be used to determine the level of performance achieved specifically for F006 wastes. The available high temperature metals recovery data that include treatment of F006 waste are shown in Table 4-2. As can be seen, the untreated waste data represent a range of wastes including D007, F006, K061, K062, carbon fines, unspecified grindings, slag, and other wastes. The data were taken over a 5-month period (January through May of 1988), and analyses were performed for 12 different metals including chromium, lead, and nickel.

The treated waste data, shown in Table 4-3, do not correspond to the untreated waste data shown in Table 4-2; however, these data represent treatment of the same type of wastes described above. The available data do not provide any information as to the percentage of F006 in the untreated wastes from which the treated waste data were generated.

4.3 Vitrification

For vitrification, EPA has performance data from one facility. The data consists of one data set showing the total concentration in the untreated waste and the TCLP leachate concentrations in the treated waste. EPA does not have data showing the concentrations of TCLP leachate of the untreated waste, nor does the Agency have data on the specific types or amounts of additives used in the vitrification process. The data on this process are shown in Table 4-4.

Table 4-1 Performance Data for Untreated and Treated F006 Wastes

Source	Oil and grease (mg/kg)	TOC (mg/kg)	Mix ratio[a]	Metal concentrations (ppm)										
				Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown														
Unstabilized														
As received	1,520	14,600		-	36.4	1.3	1270	40.2	35.5	-	435	-	2.3	1560
TCLP				<0.01	0.08	0.01	0.34	0.15	0.26	<0.001	0.71	<0.01	0.01	0.16
Stabilized														
TCLP			0.2	<0.01	0.12	0.01	0.51	0.20	0.30	<0.001	0.04	0.06	0.03	0.03
Auto part manufacturing														
Unstabilized														
As received	60	1,500		-	21.6	31.3	755	7030	409	-	989	-	6.62	4020
TCLP				<0.01	0.32	2.21	0.76	368	10.7	<0.001	22.7	<0.01	0.14	219
Stabilized														
TCLP			0.2	<0.01	0.50	0.50	0.40	5.4	0.40	<0.001	1.5	0.06	0.03	36.9
TCLP			0.5	<0.01	0.42	0.01	0.39	0.25	0.36	<0.001	0.03	0.11	0.05	0.01
Aircraft overhauling														
Unstabilized														
As received	37,000	137,000		-	85.5	67.3	716	693	25.7	-	259	-	39	631
TCLP				0.01	1.41	1.13	0.43	1.33	0.26	<0.001	1.1	<0.01	0.02	5.41
Stabilized														
TCLP			0.2	<0.01	0.33	0.06	0.08	1.64	0.30	<0.001	0.23	0.07	0.20	0.05
TCLP			0.5	<0.01	0.31	0.02	0.20	1.84	0.41	<0.001	0.15	0.11	0.05	0.03
Aerospace manufacturing (mixture of F006 & F007)														
Unstabilized														
As received	3,870	8,280		-	0.74	1.69	12.9	18.6	11.4	-	234	-	6.26	8.86
TCLP				<0.01	0.83	0.66	7.58	4.12	6.86	0.003	158	<0.01	1.64	2.28
Stabilized														
TCLP			1.0	<0.01	0.52	<0.01	0.40	0.23	0.20	<0.001	4.35	0.17	0.09	0.05
TCLP			1.5	<0.01	1.18	0.01	0.34	0.19	0.36	<0.001	2.47	0.20	0.15	0.03

Table 4 1 (Continued)

Source	Oil and grease (mg/kg)	TOC (mg/kg)	Mix ratio[a]	Metal concentrations (ppm) Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Zinc plating														
Unstabilized														
As received	1,150	21,200		-	17.2	1.30	110	1510	88.5		37	-	9.05	90200
TCLP				-	0.84	0.22	0.18	4.6	0.45	<0.001	0.52	-	0.16	2030
Stabilized														
TCLP			0.2	<0.01	0.20	0.01	0.23	0.30	0.30	<0.001	0.10	0.08	0.03	32
TCLP			0.5	<0.01	0.23	0.01	0.30	0.27	0.34	<0.001	0.02	0.14	0.04	0.04
Unknown														
Unstabilized														
As received	20,300	28,600		-	14.3	720	12200	160	52	-	701	-	5.28	35900
TCLP				<0.01	0.38	23.6	25.3	1.14	0.45	<0.001	9.78	<0.01	0.08	867
Stabilized														
TCLP			0.2	<0.01	0.31	3.23	0.25	0.20	0.24	<0.001	0.53	0.04	0.04	3.4
TCLP			0.5	<0.01	0.19	0.01	0.38	0.29	0.36	<0.001	0.04	0.09	0.06	0.03
mall engine manufacturing														
Unstabilized														
As received	2,770	6,550		-	24.5	7.28	3100	1220	113	-	19400	-	4.08	27800
TCLP				<0.01	0.07	0.3	38.7	31.7	3.37	0.003	730	<0.01	0.12	1200
Stabilized														
TCLP			0.2	<0.01	0.30	0.02	0.21	0.21	0.30	<0.001	16.5	0.05	0.03	36.3
TCLP			0.5	<0.01	0.33	0.01	0.76	0.20	0.36	<0.001	0.05	0.11	0.05	0.04
Circuit board manufacturing[b]														
Unstabilized														
As received	130	550		-	12.6	5.39	42900	10600	156	-	13000	-	12.5	120
TCLP				<0.01	0.04	0.06	360	8.69	1.0	<0.001	152	<0.01	0.05	0.62
Stabilized														
TCLP			0.2	<0.01	0.04	0.01	3.0	0.40	0.30	<0.001	0.40	0.04	0.03	0.02
TCLP			0.5	<0.01	0.14	0.01	1.21	0.42	0.38	<0.001	0.10	0.07	0.05	0.02

Table 4 1 (Continued)

Source	Oil and grease (mg/kg)	TOC (mg/kg)	Mix ratio[a]	Metal concentrations (ppm)										
				Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown														
Unstabilized														
As received	30	10,700		-	15.3	5.81	47.9	17600	169	-	23700	-	8.11	15700
TCLP				<0.01	0.53	0.18	0.04	483	4.22	<0.001	644	<0.01	0.31	650
Stabilized														
TCLP			0.2	<0.01	0.32	0.01	0.10	0.50	0.31	<0.001	15.7	0.07	0.03	4.54
TCLP			0.5	<0.01	0.27	0.01	0.2	0.32	0.37	<0.001	0.04	0.07	0.05	0.02
Unknown														
Unstabilized														
As received	1,430	5,960		-	19.2	5.04	644	27400	24500	-	5730	-	19.1	322
TCLP				0.88	0.28	0.01	0.01	16.9	50.2	<0.001	16.1	<0.45	<0.01	1.29
Stabilized														
TCLP			0.2	<0.02	0.19	<0.01	0.03	3.18	2.39	<0.001	1.09	<0.01	<0.01	0.07
TCLP			0.5	<0.02	0.08	<0.01	0.21	0.46	0.27	<0.001	0.02	<0.01	<0.01	<0.01

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[a] Mix ratio = $\frac{\text{weight of reagent}}{\text{weight of waste}}$

[b] Circuit board manufacturing waste is not in its entirety defined as F006; however, an integral part of the manufacturing operation is electroplating. Treatment residuals generated from treatment of these electroplating wastes are F006.

Source: CWM 1987.

Table 4 2 Untreated Wastes for Recovery in Rotary Hearth Furnace

January 1988

Material	Values in percent														
	Fe	Cr	Ni	Mn	Cu	Co	Mo	P	C	S	Zn	Pb	SiO_2	CaO	MgO	Al_2O_3
D007	39.30	9.76	4.99	1.25	0.41	0.22	0.26	0.025	0.50	0.48	0.08	0.20	2.97	0.85	0.61	0.31
D007	22.30	17.50	3.90	0.26	0.13	0.60	1.50	0.010	0.12	0.08	0.05	0.12	0.40	0.26	0.41	0.37
D007	7.40	6.00	35.00	0.43	0.06	0.07	0.05	0.010	0.80	0.20	0.10	0.10	1.20	1.50	0.13	0.15
D007	22.20	7.30	17.90	0.30	2.70	0.02	0.07	0.043	0.81	0.16	0.10	0.11	2.60	2.40	0.11	2.80
D007	0.28	13.40	0.01	0.10	0.01	0.11	0.11	0.010	0.02	0.01	0.01	0.01	0.66	0.88	0.05	84.00
D007	0.35	8.10	0.01	0.01	0.01	0.01	0.10	0.010	0.02	0.01	0.10	0.10	0.75	0.91	0.02	89.00
D007	4.30	0.40	0.10	0.10	0.05	0.07	0.01	0.010	0.24	0.15	0.05	0.05	0.12	1.90	1.20	14.10
F006	13.00	4.20	24.20	0.24	0.23	0.06	0.05	1.200	1.30	2.20	0.16	0.24	4.80	10.60	2.00	0.20
K061	28.20	8.42	2.61	3.97	0.53	0.16	0.50	0.030	0.50	0.40	4.20	1.12	7.88	8.70	4.47	0.87
K061	20.60	1.80	0.10	3.80	0.14	0.04	0.07	0.045	1.70	0.23	0.39	0.18	8.10	29.96	17.09	0.91
K062	35.30	9.38	3.63	2.08	0.56	0.34	0.33	0.066	0.30	0.30	1.52	0.42	4.40	8.38	2.35	0.90
K062	37.50	6.00	5.92	0.70	0.30	0.25	0.18	0.046	0.30	0.25	0.03	0.19	13.30	0.50	0.72	0.63
Carbon Fines	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.019	85.00	0.50	0.00	0.00	5.00	0.00	0.00	2.00
Grindings	58.70	10.30	5.80	0.85	0.80	0.15	0.44	0.023	1.50	1.30	0.12	0.12	2.50	1.50	0.40	1.20
Grindings	53.70	8.50	9.50	0.75	0.90	1.50	0.85	0.031	1.51	1.29	0.52	0.23	2.30	1.61	0.42	1.31
Mill Scale	52.40	8.34	2.63	1.00	0.45	0.18	0.32	0.019	0.50	0.20	0.10	0.10	2.50	2.20	0.30	1.50
Miscellaneous	0.83	0.09	0.15	0.10	2.70	0.06	0.05	0.190	70.00	4.60	0.19	0.01	3.40	0.01	0.01	0.57
Nonhaz Waste	32.10	1.70	1.40	1.00	0.14	0.01	0.12	0.066	4.20	0.44	7.90	2.30	9.30	7.80	2.00	3.40
Slag	26.20	4.10	12.10	0.66	0.18	0.98	1.00	0.010	0.10	0.30	0.49	0.19	1.50	1.60	0.97	0.66
Swarf	62.80	9.13	6.48	1.44	0.60	0.47	0.40	0.035	1.10	0.30	0.15	0.13	4.18	0.50	0.23	3.80

Table 4.2 (Continued)

February 1988

Material	Fe	Cr	Ni	Mn	Cu	Co	Mo	P	C	S	Zn	Pb	SiO_2	CaO	MgO	Al_2O_3
	Values in percent															
D007	42.70	7.30	5.50	1.00	0.14	0.01	0.12	0.066	4.20	0.44	7.90	2.30	9.30	7.80	2.00	3.40
D007	37.40	7.20	5.00	0.24	0.23	0.06	0.05	0.016	1.30	2.20	0.16	0.24	4.80	10.60	2.00	0.20
D007	37.30	9.90	4.40	1.33	0.48	0.19	0.29	0.015	0.50	0.48	0.03	0.16	1.10	0.34	0.45	0.32
D007	28.30	3.20	13.30	0.36	0.15	0.25	0.94	0.012	0.12	0.08	0.05	0.10	0.58	0.47	0.73	0.42
D007	24.40	6.20	10.00	0.29	4.10	0.10	0.05	0.040	0.80	0.20	0.07	0.07	3.00	3.04	0.11	1.99
D007	7.40	6.60	36.50	0.44	0.06	0.07	0.05	0.020	0.81	0.16	0.01	0.07	1.40	1.07	0.10	0.18
D007	9.40	8.00	32.30	0.43	0.06	0.08	0.05	0.028	0.10	0.30	0.09	0.11	3.80	2.29	0.24	0.21
D007	22.50	3.20	17.80	0.34	0.17	0.72	0.71	0.010	0.02	0.01	0.10	0.14	0.90	0.24	0.43	0.38
D007	24.80	9.30	3.50	0.10	0.05	0.06	0.01	0.044	0.24	0.15	0.05	0.05	4.80	1.90	1.20	0.13
D007	35.50	13.30	3.70	1.50	0.43	0.17	0.28	0.02	0.00	0.00	0.02	0.16	2.30	0.35	0.33	0.23
D007	39.10	7.70	5.10	0.96	0.39	0.21	0.22	0.02	0.00	0.00	0.02	0.20	0.76	0.28	0.15	0.08
K061	27.10	8.34	2.42	4.44	0.49	0.13	0.55	0.026	0.50	0.40	5.22	1.10	8.00	8.14	5.21	0.88
K062	34.10	9.16	3.18	2.36	0.53	0.27	0.40	0.052	0.30	0.30	1.49	0.51	4.68	9.04	3.30	0.89
K062	36.50	6.60	5.60	0.67	0.24	0.25	0.17	0.072	0.30	0.25	0.02	0.14	16.03	0.34	0.77	0.99
K062	47.40	14.50	1.00	0.01	0.09	0.10	0.11	0.0.6	0.02	0.01	0.10	0.10	0.75	0.50	0.02	0.10
K062	21.00	29.10	1.30	0.10	0.18	0.05	0.11	0.010	0.00	4.60	0.19	0.01	0.50	0.01	0.01	0.50
K062	28.50	4.20	6.00	0.40	0.25	0.22	0.16	0.06	0.00	0.00	0.03	0.15	29.00	0.34	0.44	1.28
K062	30.20	4.50	6.30	0.44	0.26	0.22	0.14	0.05	0.00	0.00	0.03	0.23	26.10	0.37	0.46	1.29
Carbon Fines	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.019	85.00	0.50	0.00	0.00	5.00	0.00	0.00	2.00
Grindings	56.70	10.30	5.80	0.85	0.80	0.15	0.44	0.023	1.50	1.30	0.12	0.12	2.50	1.50	0.40	1.20
Grindings	51.50	9.30	11.60	0.75	0.69	1.33	1.03	0.026	1.51	1.29	0.52	0.23	6.20	1.61	0.42	2.36
Grindings	54.00	8.70	11.30	0.10	0.78	0.76	0.51	0.035	0.10	0.10	0.10	0.10	1.35	0.10	0.10	0.94
Mill Scale	53.50	8.10	2.65	1.00	0.47	0.18	0.32	0.018	0.50	0.20	0.10	0.10	2.50	2.20	0.30	1.50
Swarf	59.80	9.62	5.72	1.12	0.39	0.23	0.27	0.043	1.10	0.30	0.04	0.20	0.88	0.26	0.38	0.21

Table 4.2 (Continued)

March 1988

Material	Values in percent															
	Fe	Cr	Ni	Mn	Cu	Co	Mo	P	C	S	Zn	Pb	SiO_2	CaO	MgO	Al_2O_3
D007	33.50	15.60	4.20	1.75	0.31	0.18	0.40	0.016	4.20	0.44	0.70	0.32	1.00	0.76	0.40	0.36
D007	37.35	7.52	4.92	1.50	0.31	0.20	0.28	0.0.5	1.30	2.20	0.02	0.20	1.00	0.55	0.25	0.10
D007	26.20	7.30	4.40	1.43	0.38	0.20	0.36	0.018	0.50	0.48	0.05	0.22	1.00	0.39	0.21	0.14
D007	23.00	3.60	20.10	0.30	0.15	0.18	0.22	0.015	0.12	0.08	0.10	0.05	0.90	0.50	0.33	0.50
D007	7.35	6.50	35.00	0.64	0.06	0.12	0.02	0.044	0.80	0.20	0.01	0.08	1.52	1.70	0.12	0.19
D007	6.90	6.30	35.00	0.62	0.07	0.10	0.05	0.047	0.81	0.16	0.02	0.07	1.50	1.66	0.12	0.23
D007	26.70	8.10	12.20	0.22	2.40	0.10	0.05	0.036	0.10	0.30	0.05	0.07	2.30	2.20	0.12	3.40
D007	37.00	9.20	4.79	1.42	0.48	0.18	0.27	0.014	0.00	0.00	0.06	0.24	0.75	0.29	0.22	0.16
D007	40.10	7.10	5.74	1.09	0.47	0.22	0.25	0.019	0.00	0.00	0.02	0.22	0.91	0.63	0.18	0.23
D007	40.90	8.30	5.59	1.34	0.51	0.21	0.27	0.018	0.00	0.00	0.04	0.21	1.20	1.12	0.56	0.24
D007	30.20	4.50	6.69	0.44	0.26	0.22	0.14	0.049	0.00	0.00	0.03	0.23	26.10	0.37	0.46	1.29
D007	39.50	9.90	4.89	1.00	0.34	0.20	0.19	0.017	0.00	0.00	0.03	0.17	1.10	0.70	0.40	0.30
D007	6.70	6.60	32.50	0.55	0.06	0.40	0.05	0.200	0.00	0.00	0.02	0.07	2.10	1.55	0.40	0.20
D007	6.90	5.90	35.70	0.50	0.06	0.09	0.05	0.035	0.00	0.00	0.05	0.08	1.90	4.20	0.17	0.20
K061	26.51	8.39	2.52	4.51	0.54	0.13	0.72	0.023	0.50	0.40	4.55	0.99	7.55	9.00	6.12	0.84
K062	34.58	10.10	4.04	2.10	0.55	0.35	0.37	0.041	0.30	0.30	1.44	0.50	5.10	7.45	2.20	0.81
K062	36.00	5.30	5.89	0.48	0.25	0.26	0.14	0.055	0.30	0.25	0.02	0.15	25.60	0.31	0.39	1.14
K062	30.20	4.70	4.69	0.46	0.24	0.18	0.15	0.057	0.50	0.30	0.02	0.20	22.30	0.40	0.60	1.07
K062	31.70	4.60	5.69	0.41	0.22	0.23	0.18	0.055	0.02	0.01	0.05	0.16	18.20	0.34	0.58	1.02
K062	58.10	19.90	2.00	0.10	0.13	0.20	0.17	0.016	0.02	0.01	0.10	0.10	0.24	0.50	0.02	0.12
K062	35.20	6.80	5.89	0.54	0.25	0.24	0.14	0.053	0.24	0.15	0.04	0.22	18.90	0.37	0.41	0.91
K062	3.00	0.01	0.01	0.01	0.01	0.01	0.01	0.030	72.40	1.00	0.01	0.01	9.80	1.70	0.50	4.60
K062	28.50	4.60	6.19	0.44	0.23	0.20	0.16	0.063	0.30	0.30	0.02	0.20	0.50	2.80	0.80	2.00
Carbon Fines	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.019	85.00	0.50	0.00	0.00	5.00	0.00	0.00	2.00
Ferro Silicon	66.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	33.50	0.00	0.00	0.00
Grindings	58.70	10.30	5.98	0.85	0.80	0.15	0.44	0.023	1.50	1.30	0.12	0.12	2.50	1.50	0.40	1.20
Mill Scale	53.87	8.85	2.93	0.77	0.57	0.13	0.30	0.024	0.50	0.20	0.10	0.10	3.20	1.84	0.15	1.07
Nonhaz Waste	80.40	5.00	4.10	0.68	0.14	0.01	0.35	0.024	0.10	0.10	0.10	0.10	0.80	0.01	0.01	0.01
Pellets	58.00	0.15	0.15	0.40	0.10	0.10	0.10	0.022	0.30	0.30	0.02	0.20	0.50	2.80	0.80	2.00
Swarf	60.21	10.85	5.55	2.12	0.45	0.10	0.59	0.038	1.10	0.30	0.04	0.20	6.43	1.39	0.10	7.60
Swarf	46.50	12.00	6.50	1.00	0.27	0.25	0.30	0.034	0.00	0.00	0.00	0.00	5.10	2.10	0.35	2.50

Table 4 2 (Continued)

April 1988

Material	Fe	Cr	Ni	Mn	Cu	Co	Mo	P	C	S	Zn	Pb	SiO_2	CaO	MgO	Al_2O_3
	Values in percent															
D007	36.00	11.38	4.10	0.98	0.39	0.26	0.30	0.023	1.30	2.20	0.03	0.19	1.04	0.43	0.23	0.18
D007	20.97	4.99	17.55	0.31	0.15	1.48	0.87	0.012	0.17	0.08	0.04	0.10	0.60	0.21	0.25	0.55
D007	14.76	7.31	25.85	0.81	0.61	0.15	0.04	0.039	0.80	0.20	0.05	0.07	1.92	2.59	0.36	1.45
D007	0.56	9.20	0.00	0.00	0.00	0.00	0.00	0.010	0.00	0.00	0.00	0.00	0.64	8.40	0.66	0.96
F006	12.80	6.20	32.30	0.00	0.65	0.00	0.06	0.150	0.10	0.30	0.00	0.00	6.00	0.00	0.00	0.00
K061	27.88	10.10	2.29	4.58	0.56	0.14	0.73	0.022	0.50	0.40	4.01	0.99	7.25	8.16	5.22	0.75
K062	33.10	9.71	3.04	2.91	0.64	0.23	0.46	0.032	0.30	0.30	2.60	0.70	5.44	6.48	2.81	0.90
K062	37.16	6.00	4.84	0.57	0.24	0.25	0.13	0.061	0.30	0.25	0.12	0.14	18.22	0.65	0.68	1.02
K062	37.70	25.30	0.87	0.10	0.10	0.20	0.19	0.010	0.02	0.01	0.10	0.10	0.24	0.50	0.02	0.12
Carbon Fines	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.109	85.00	0.50	0.00	0.00	5.00	0.00	0.00	2.00
Ferro Silicon	66.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	33.50	0.00	0.00	0.00
Grindings	63.57	8.57	10.77	0.85	0.93	0.36	0.59	0.035	1.50	1.30	0.12	0.12	1.63	1.50	0.40	1.53
Mill Scale	53.60	9.50	3.40	0.77	0.65	0.15	0.30	0.023	0.50	0.20	0.10	0.10	3.20	1.84	0.15	1.07
Pellets	58.00	0.15	0.15	0.40	0.10	0.10	0.10	0.022	0.30	0.30	0.02	0.20	0.50	2.80	0.80	2.00
Swarf	59.60	10.70	5.80	2.12	0.51	0.57	0.33	0.039	1.10	0.30	0.04	0.20	6.87	1.39	0.10	5.25
Swarf	46.50	12.00	6.50	1.00	0.27	0.25	0.30	0.034	0.00	0.00	0.00	0.00	5.10	2.10	0.35	2.50

Table 4 2 (Continued)

May 1988

Material	Values in percent															
	Fe	Cr	Ni	Mn	Cu	Co	Mo	P	C	S	Zn	Pb	SiO_2	CaO	MgO	Al_2O_3
D007	34.89	9.89	4.55	0.72	0.47	0.18	0.27	0.019	1.30	2.20	0.09	0.17	1.28	0.42	0.32	0.33
D007	15.60	13.66	12.70	0.43	0.14	0.47	1.23	0.009	0.50	0.30	0.15	0.13	1.04	0.46	0.56	0.39
D007	27.98	6.68	5.57	0.65	2.28	0.11	0.07	0.028	0.80	0.20	0.05	0.12	6.24	10.93	0.71	6.46
D007	0.56	9.20	0.00	0.00	0.00	0.00	0.00	0.010	0.00	0.00	0.00	0.00	0.64	8.40	0.66	0.96
D007	62.20	5.90	0.09	0.50	0.02	0.08	0.05	0.075	2.30	0.03	0.00	0.00	0.75	0.50	0.20	0.13
F006	12.80	6.20	32.30	0.00	0.65	0.00	0.06	0.150	0.10	0.30	0.00	0.00	6.00	0.00	0.00	0.00
K061	27.60	10.00	2.46	4.49	0.57	0.13	0.59	0.020	0.50	0.40	4.68	1.24	6.65	8.76	4.59	0.77
K062	45.00	10.10	0.85	0.00	0.55	0.10	0.05	0.025	3.60	0.26	0.00	0.00	50.70	1.80	4.10	8.30
K062	37.26	9.67	3.21	1.46	0.53	0.32	0.31	0.044	0.30	0.30	0.88	0.31	4.37	8.36	2.43	0.71
K062	40.91	7.20	5.06	0.62	0.24	0.28	0.13	0.048	0.30	0.25	0.02	0.12	9.17	0.22	0.27	0.50
K062	37.70	25.30	0.87	0.10	0.10	0.20	0.19	0.010	0.02	0.01	0.10	0.10	0.24	0.50	0.02	0.12
Carbon Fines	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.019	85.00	0.50	0.00	0.00	5.00	0.00	0.00	2.00
Ferro Silicon	66.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	33.50	0.00	0.00	0.00
Grindings	26.00	10.00	22.40	0.31	0.22	0.62	2.10	0.044	0.12	0.08	0.04	0.10	6.89	0.21	0.25	12.04
Grindings	51.95	9.70	12.94	0.85	1.08	0.33	0.66	0.027	1.50	1.30	0.12	0.12	1.76	1.50	0.40	1.07
Mill Scale	58.50	9.90	3.90	0.77	0.50	0.13	0.25	0.020	0.50	0.20	0.10	0.10	3.20	1.84	0.15	1.07
Nonhaz Waste	0.01	0.01	5.88	0.00	0.01	0.15	0.00	0.005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Swarf	53.40	11.74	7.00	2.12	0.57	0.44	0.38	0.034	1.10	0.30	0.04	0.20	6.26	1.39	0.10	4.13

Table 4-3 High Temperature Metals Recovery-Treated Samples

	Cr (%)	Mg (%)	Ca (%)	Si (%)	MgO (%)	CaO (%)	SiO_2 (%)	Al_2O_3 (%)
Ave %	3.32	8.86	20.27	10.60	14.37	28.38	22.68	
Max %	7.64	10.20	23.80	12.45	16.93	33.32	26.64	
Low %	0.83	6.73	16.80	8.55	11.27	22.40	18.30	
March # of samples	186	186	186	186	186	186	186	-
Ave %	3.03				15.71	26.10	22.51	15.55
Max %	5.75				32.54	30.04	27.26	16.25
Low %	0.73				12.19	16.80	19.26	14.99
April # of Samples	159	-	-	-	159	159	159	3
Ave %	3.61				14.33	27.09	21.98	
Max %	6.50				17.41	31.15	26.10	
Low %	0.85				11.66	23.23	18.93	
May # of Samples	146	-	-	-	146	146	146	-
TOTAL #	491				491	491	491	3

Note: The treated data represent 491 slag assays covering the period March through May 1988. For each metal for which data were provided, the table shows the reported number of data points for that metal, the average value, the maximum value, and the minimum values. Values are reported as percentages. Slag assays include residues resulting from the rotary hearth furnace treatment of the following wastes: K061, K062, F006, D007, mill scale, swarf, slag, carbon fines, nonhazardous waste, miscellaneous, and grindings. In addition, the slag also includes residue resulting from electric arc smelting furnace treatment of cold reduced pellets, EF carbon, dolomite, and mill scale.

Table 4-4 Vitrification of F006

Constituent	Untreated (mg/kg)	Treated TCLP values (mg/l)
Antimony	-	<0.06
Arsenic	-	<0.01
Barium	-	<0.2
Beryllium	-	<0.005
Cadmium	4.5	<0.005
Chromium	30,600	0.089
Copper	17	6.0
Lead	1,760	<0.005
Mercury	-	<0.0002
Nickel	61,040	11.0
Selenium	-	<0.005
Silver	-	<0.01
Thallium	-	<0.01
Zinc	13,700	0.10

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY

In this section, EPA explains its determination of which technology represents the "best" level of performance in addition to being demonstrated and available. As discussed in Section 3, the demonstrated treatment technologies are stabilization, metals recovery, and vitrification.

As shown in Section 4, some performance data is available for all of the demonstrated technologies. The data on high temperature metals recovery and vitrification, however, are insufficient to assess the level of treatment achieved by these technologies on F006 wastes. EPA finds, therefore, that available data support stabilization as the technology that provides the "best" level of performance for F006 wastes. Note: Both high temperature metals recovery and vitrification can be used to treat F006 wastes provided these technologies achieve the performance-based treatment standards. Additionally, EPA may reevaluate these technologies as candidates for BDAT if more data become available.

In addition to being "best," stabilization is also "available" in that it is commercially available and provides substantial treatment. In determining whether stabilization provides "substantial" treatment, EPA first evaluated the data base (shown in Section 4) to determine whether any data should be deleted because the data are generated from treatment of wastes determined to be less representative of F006 than other wastes for which EPA has treatment data. EPA's review of the data showed that waste from the aerospace manufacturing industry contained both F006 and

F007 wastes. EPA deleted these data from consideration because the Agency had other data on treatment of F006 wastes alone and because EPA had no information as to the percentage of F006 and F007 in the aerospace industry waste.

EPA's assessment of substantial treatment also included review of the data to determine whether any data should be deleted because they could be shown to not represent a well-designed and/or well-operated system. EPA reviewed the treatment data associated with each binder-to-waste ratio and deleted data from the less effective binder-to-waste ratio; this process resulted in deletion of 99 treated data points (see Table D-1 in Appendix D for specific constituents deleted). Other data were deleted for individual constituents for one of the following reasons: (1) the treated leachate concentration was higher than the untreated waste leachate concentration; (2) insufficient information was present on the untreated constituent to determine treatment effectiveness (i.e., without the untreated leachate value, it is not possible to determine whether the treated leachate value represents a significant reduction); (3) the untreated leachate concentration was already at a low level (at or below 0.02 ppm), and therefore the treated value is not meaningful in determining treatment performance; and (4) the treated level of performance could be attributed solely to dilution from the binder. The specific constituents deleted for each rationale are shown in Table D-1 in Appendix D.

In general, although a specific leachable concentration of constituent may not be reduced or, in some cases, may increase after stabilization, EPA does not believe that this is the basis for eliminating consideration of the sample where substantial treatment occurs. We believe this approach is reasonable in that the data not used are the anomalous results that will occur when constituents are at or below the treatable concentrations. (When operating near minimum solubilities, small changes in pH, for example, can cause increases in leachable concentrations.) We believe that this in no way affects the results where substantial treatment of other constituents occurs. By only using the data where treatment occurred, EPA has essentially assumed that each waste has the highest observed concentrations from any waste in every waste. This approach obviously is conservative with respect to the ability of any specific generator to comply with the standard. This is clearly supported by the fact that no measurement in any of EPA's TCLP data base exceeded the promulgated standard when the proper chemical binders and mix ratio were used.

Further, it has been alleged that EPA's data base for F006 has been somehow tainted by the fact that additional testing by the same data source using different kiln dusts did not achieve the same zinc and copper performances. The data source has denied that this is the case, and EPA sees no technical basis for such an assumption. If, in fact, zinc and copper performance was not attained with other kiln dusts, it was more likely the result of the zinc and copper content of the specific kiln dusts than of any specific matrix impact on the pozzolanic capture of the metals. However, EPA will consider any data supporting other conclusions.

The performance data that EPA used in assessing substantial treatment are shown in Table 5-1. As shown, stabilization achieved reductions in the leachate value for all of the metals selected for regulation. (Section 6 presents a detailed discussion of constituents selected for regulation.) Specifically, leachate reductions were as high as 2.2 mg/l for cadmium, 358 mg/l for chromium, 49 mg/l for lead, 729 mg/l for nickel, and 0.25 mg/l for silver.

The Agency believes the reduction in the range and magnitude of the various hazardous constituents to be substantial. Stabilization has been determined to be demonstrated and best, has provided substantial treatment, and is commercially available; therefore, stabilization represents BDAT for F006 nonwastewaters.

Table 5-1 Accuracy-Corrected Performance Data for Untreated and Treated F006 Wastes by Stabilization

Source	Mix ratio[a]	Metal concentrations (ppm)							
		Barium	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc
Unknown									
Unstabilized									
As received		-	-	-	-	-	435	-	1560
TCLP		-	-	-	-	-	0.71	-	0.16
Stabilized									
TCLP	0.2	-	-	-	-	-	0.05	-	0.03
Auto part manufacturing									
Unstabilized									
As received		-	31.3	755	7030	409	989	6.62	4020
TCLP		-	2.21	0.76	638	10.7	22.7	0.14	219
Stabilized									
TCLP	0.5	-	0.01	0.45	0.27	0.39	0.03	0.06	0.01
Aircraft overhauling									
Unstabilized									
As received		85.5	67.3	716	-	-	259	-	631
TCLP		1.41	1.13	0.43	-	-	1.1	-	5.41
Stabilized									
TCLP	0.2	0.34	0.06	0.09	-	-	0.27	-	0.03
Zinc plating									
Unstabilized									
As received		17.2	1.30	-	1510	-	37	9.05	90,200
TCLP		0.84	0.22	-	4.6	-	0.52	0.16	2050
Stabilized									
TCLP	0.5	0.25	0.01	-	0.21	-	0.02	0.05	0.04
Unknown									
Unstabilized									
As received		14.3	720	12,200	160	-	701	-	25,900
TCLP		0.38	23.6	25.3	1.14	-	9.78	-	867
Stabilized									
TCLP	0.5	0.21	0.01	0.44	0.31	-	0.04	-	0.03

Table 5 1 (Continued)

Source	Mix ratio[a]	Metal concentrations (ppm)							
		Barium	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc
Small engine manufacturing									
Unstabilized									
As received		-	7.28	3,100	1220	113	19,400	4.08	27,800
TCLP		-	0.3	38.7	31.7	3.37	730	0.12	1200
Stabilized									
TCLP	0.5	-	0.01	0.89	0.31	0.39	0.06	0.06	0.040
Circuit board manufacturing									
Unstabilized									
As received		-	5.39	42,900	10,600	156	13,000	-	120
TCLP		-	0.06	360	8.69	1.0	152	-	0.62
Stabilized									
TCLP	0.5	-	0.01	1.41	0.45	0.41	0.11	-	0.020
Unknown									
Unstabilized									
As received		15.3	5.81	-	17,600	169	23,700	8.11	15,700
TCLP		0.53	0.18	-	483	4.22	644	0.31	650
Stabilized									
TCLP	0.5	0.294	0.01	-	0.35	0.40	0.04	0.06	0.020
Unknown									
Unstabilized									
As received		19.2	-	-	27,400	24,500	5,730	-	322
TCLP	-	0.28	-	-	16.9	50.2	16.1	-	1.29
Stabilized									
TCLP	0.5	0.087	-	-	0.50	0.29	<0.02	-	<0.01

[a] Mix ratio = $\frac{\text{weight of reagent}}{\text{weight of waste}}$

Source: CWM 1987.

6. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (Table 1-1) from which the constituents to be regulated are selected. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous insecticides, PCBs, and dioxins and furans.

This section describes the selection of the constituents to be regulated for K061. In general, EPA regulates all constituents that are found in the untreated waste at treatable concentrations and are not likely to be reduced by regulation of other constituents. As noted in the Executive Summary, EPA is regulating only specific constituents for K061 where the treatment technology represents stabilization.

6.1 Identification of BDAT List Constituents in F006 Waste

As discussed in Sections 2 and 4, the Agency has characterization data as well as performance data from treatment of F006. All these data, as well as information on the waste generating process, have been used to determine which BDAT list constituents may be present in the waste and therefore are potential candidates for regulation in F006 nonwastewater.

Table 6-1, a standard table for the First Third wastes background documents, shows which constituents were analyzed, which constituents were detected, and which constituents the Agency believes to be present even though not detected in the untreated waste. For constituents that were detected, the concentration range is shown.

Under the column "Believed to be present," constituents other than those detected in the untreated waste are marked with an X or Y if EPA believes they are likely to be present in the untreated waste. For those constituents marked with X, an engineering analysis of the waste generating process indicates that they are likely to be present (e.g., the engineering analysis shows that a particular constituent is a major raw material). Those constituents marked with Y have been detected in the treated residual(s), and thus EPA believes that they are present in the untreated waste. Constituents may not have been detected in the untreated waste for one of several reasons: (1) none of the untreated waste samples were analyzed for these constituents, (2) masking or interference by other constituents prevented detection, and/or (3) the constituent is indeed not present (such a case can occur when the waste of concern is defined as being generated by a process and the process can involve a number of different constituents, only some of which would be present in any given sample).

6.2 Selection of Constituents

As shown in Table 6-1, 15 constituents have been detected and no additional constituents have been identified as believed to be present. Of these constituents, EPA has selected cadmium, chromium, lead, nickel, and silver for regulation. Of the remaining constituents not being regulated, 7 are believed to be treatable. EPA is not regulating copper and zinc because these constituents are not in Appendix VIII as elemental constituents but rather are listed in Appendix VIII as specific metal compounds (i.e., copper cyanide, zinc phosphate, and zinc cyanide).

Regulation of the other BDAT metals will reduce leachate concentrations of both these metals. EPA is not regulating any of the other treatable constituents because the untreated leachate concentrations of these metals are far below the regulated constituents.

Table 6-1 Status of BDAT List Constituent Presence in Untreated F006 Waste

BDAT reference no.	Constituent	Detection status^a	Believed to be present
	Volatile organics		
222.	Acetone	ND	
1.	Acetonitrile	NA	
2.	Acrolein	NA	
3.	Acrylonitrile	NA	
4.	Benzene	NA	
5.	Bromodichloromethane	ND	
6.	Bromomethane	ND	
223.	n-Butyl alcohol	NA	
7.	Carbon tetrachloride	ND	
8.	Carbon disulfide	ND	
9.	Chlorobenzene	ND	
10.	2-Chloro-1,3-butadiene	NA	
11.	Chlorodibromomethane	ND	
12.	Chloroethane	ND	
13.	2-Chloroethyl vinyl ether	ND	
14.	Chloroform	ND	
15.	Chloromethane	ND	
16.	3-Chloropropene	NA	
17.	1,2-Dibromo-3-chloropropane	NA	
18.	1,2-Dibromoethane	NA	
19.	Dibromomethane	NA	
20.	trans-1,4 Dichloro 2 butene	NA	
21.	Dichlorodifluoromethane	ND	
22.	1,1-Dichloroethane	ND	
23.	1,2-Dichloroethane	ND	
24.	1,1-Dichloroethylene	ND	
25.	trans-1,2-Dichloroethene	ND	
26.	1,2-Dichloropropane	ND	
27.	trans-1,3-Dichloropropene	ND	
28.	cis-1,3-Dichloropropene	ND	
29.	1,4-Dioxane	NA	
224.	2-Ethoxyethanol	NA	
225.	Ethyl acetate	NA	
226.	Ethyl benzene	ND	
30.	Ethyl cyanide	NA	
227.	Ethyl ether	NA	
31.	Ethyl methacrylate	NA	
214.	Ethylene oxide	NA	
32.	Iodomethane	NA	
33.	Isobutyl alcohol	NA	
228.	Methanol	NA	
34.	Methyl ethyl ketone	ND	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Volatile organics (continued)		
229.	Methyl isobutyl ketone	ND	
35.	Methyl methacrylate	NA	
37.	Methacrylonitrile	NA	
38.	Methylene chloride	ND	
230.	2-Nitropropane	NA	
39.	Pyridine	NA	
40.	1,1,1,2-Tetrachloroethane	NA	
41.	1,1,2,2-Tetrachloroethane	ND	
42.	Tetrachloroethene	ND	
43.	Toluene	ND	
44.	Tribromomethane	ND	
45.	1,1,1-Trichloroethane	NA	
46.	1,1,2-Trichloroethane	NA	
47.	Trichloroethene	ND	
48.	Trichloromonofluoromethane	NA	
49.	1,2,3-Trichloropropane	NA	
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	ND	
50.	Vinyl chloride	ND	
215.	1,2-Xylene	ND	
216.	1,3-Xylene	ND	
217.	1,4-Xylene	ND	
	Semivolatile organics		
51.	Acenaphthalene	NA	
52.	Acenaphthene	NA	
53.	Acetophenone	NA	
54.	2-Acetylaminofluorene	NA	
55.	4-Aminobiphenyl	NA	
56.	Aniline	NA	
57.	Anthracene	NA	
58.	Aramite	NA	
59.	Benz(a)anthracene	NA	
218.	Benzal chloride	NA	
60.	Benzenethiol	NA	
61.	Deleted		
62.	Benzo(a)pyrene	NA	
63.	Benzo(b)fluoranthene	NA	
64.	Benzo(ghi)perylene	NA	
65.	Benzo(k)fluoranthene	NA	
66.	p-Benzoquinone	NA	

Table 6.1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
67.	Bis(2-chloroethoxy)methane	NA	
68.	Bis(2-chloroethyl)ether	NA	
69.	Bis(2-chloroisopropyl)ether	NA	
70.	Bis(2-ethylhexyl)phthalate	NA	
71.	4-Bromophenyl phenyl ether	NA	
72.	Butyl benzyl phthalate	NA	
73.	2-sec-Butyl-4,6-dinitrophenol	NA	
74.	p-Chloroaniline	NA	
75.	Chlorobenzilate	NA	
76.	p-Chloro-m-cresol	NA	
77.	2-Chloronaphthalene	NA	
78.	2-Chlorophenol	NA	
79.	3-Chloropropionitrile	NA	
80.	Chrysene	NA	
81.	ortho-Cresol	NA	
82.	para-Cresol	NA	
232.	Cyclohexanone	NA	
83.	Dibenz(a,h)anthracene	NA	
84.	Dibenzo(a,e)pyrene	NA	
85.	Dibenzo(a,i)pyrene	NA	
86.	m-Dichlorobenzene	NA	
87.	o-Dichlorobenzene	NA	
88.	p-Dichlorobenzene	NA	
89.	3,3'-Dichlorobenzidine	NA	
90.	2,4-Dichlorophenol	NA	
91.	2,6-Dichlorophenol	NA	
92.	Diethyl phthalate	NA	
93.	3,3'-Dimethoxybenzidine	NA	
94.	p-Dimethylaminoazobenzene	NA	
95.	3,3'-Dimethylbenzidine	NA	
96.	2,4-Dimethylphenol	NA	
97.	Dimethyl phthalate	NA	
98.	Di-n-butyl phthalate	NA	
99.	1,4-Dinitrobenzene	NA	
100.	4,6-Dinitro-o-cresol	NA	
101.	2,4-Dinitrophenol	NA	
102.	2,4-Dinitrotoluene	NA	
103.	2,6-Dinitrotoluene	NA	
104.	Di-n-octyl phthalate	NA	
105.	Di-n-propylnitrosamine	NA	
106.	Diphenylamine	NA	
219.	Diphenylnitrosamine	NA	

Table 6 1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
107.	1,2-Diphenylhydrazine	NA	
108.	Fluoranthene	NA	
109.	Fluorene	NA	
110.	Hexachlorobenzene	NA	
111.	Hexachlorobutadiene	NA	
112.	Hexachlorocyclopentadiene	NA	
113.	Hexachloroethane	NA	
114.	Hexachlorophene	NA	
115.	Hexachloropropene	NA	
116.	Indeno(1,2,3-cd)pyrene	NA	
117.	Isosafrole	NA	
118.	Methapyrilene	NA	
119.	3-Methylcholanthrene	NA	
120.	4,4'-Methylenebis (2-chloroaniline)	NA	
36.	Methyl methanesulfonate	NA	
121.	Naphthalene	NA	
122.	1,4-Naphthoquinone	NA	
123.	1-Naphthylamine	NA	
124.	2-Naphthylamine	NA	
125.	p-Nitroaniline	NA	
126.	Nitrobenzene	NA	
127.	4-Nitrophenol	NA	
128.	N-Nitrosodi-n-butylamine	NA	
129.	N-Nitrosodiethylamine	NA	
130.	N-Nitrosodimethylamine	NA	
131.	N-Nitrosomethylethylamine	NA	
132.	N-Nitrosomorpholine	NA	
133.	N-Nitrosopiperidine	NA	
134.	n-Nitrosopyrrolidine	NA	
135.	5-Nitro-o-toluidine	NA	
136.	Pentachlorobenzene	NA	
137.	Pentachloroethane	NA	
138.	Pentachloronitrobenzene	NA	
139.	Pentachlorophenol	NA	
140.	Phenacetin	NA	
141.	Phenanthrene	NA	
142.	Phenol	NA	
220.	Phthalic anhydride	NA	
143.	2-Picoline	NA	
144.	Pronamide	NA	
145.	Pyrene	NA	
146.	Resorcinol	NA	

Table 6 1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Semivolatile organics (continued)		
147.	Safrole	NA	
148.	1,2,4,5-Tetrachlorobenzene	NA	
149.	2,3,4,6-Tetrachlorophenol	NA	
150.	1,2,4-Trichlorobenzene	NA	
151.	2,4,5-Trichlorophenol	NA	
152.	2,4,6-Trichlorophenol	NA	
153.	Tris(2,3-dibromopropyl) phosphate	NA	
	Metals		
154.	Antimony	<10-22.4	
155.	Arsenic	<04.-5	
156.	Barium	0.74-52	
157.	Beryllium	ND	
158.	Cadmium	0.003-4,070	
159.	Chromium (total)	<0.002-290,000	
221.	Chromium (hexavalent)	<0.001-910	
160.	Copper	1.4-28,100	
161.	Lead	<0.001-24,500	
162.	Mercury	ND	
163.	Nickel	0.06-170,000	
164.	Selenium	ND	
165.	Silver	<0.6-38.9	
166.	Thallium	ND	
167.	Vanadium	1.26	
168.	Zinc	8.86-90,200	
	Inorganics other than metals		
169.	Cyanide	<0.025-1,970	
170.	Fluoride	268	
171.	Sulfide	21	
	Organochlorine pesticides		
172.	Aldrin	NA	
173.	alpha-BHC	NA	
174.	beta-BHC	NA	
175.	delta-BHC	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Organochlorine pesticides (continued)		
176.	gamma-BHC	NA	
177.	Chlordane	NA	
178.	DDD	NA	
179.	DDE	NA	
180.	DDT	NA	
181.	Dieldrin	NA	
182.	Endosulfan I	NA	
183.	Endosulfan II	NA	
184.	Endrin	NA	
185.	Endrin aldehyde	NA	
186.	Heptachlor	NA	
187.	Heptachlor epoxide	NA	
188.	Isodrin	NA	
189.	Kepone	NA	
190.	Methoxyclor	NA	
191.	Toxaphene	NA	
	Phenoxyacetic acid herbicides		
192.	2,4-Dichlorophenoxyacetic acid	NA	
193.	Silvex	NA	
194.	2,4,5-T	NA	
	Organophosphorous insecticides		
195.	Disulfoton	NA	
196.	Famphur	NA	
197.	Methyl parathion	NA	
198.	Parathion	NA	
199.	Phorate	NA	
	PCBs		
200.	Aroclor 1016	NA	
201.	Aroclor 1221	NA	
202.	Aroclor 1232	NA	
203.	Aroclor 1242	NA	
204.	Aroclor 1248	NA	
205.	Aroclor 1254	NA	
206.	Aroclor 1260	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status[a]	Believed to be present
	Dioxins and furans		
207.	Hexachlorodibenzo-p-dioxins	NA	
208.	Hexachlorodibenzofurans	NA	
209.	Pentachlorodibenzo-p-dioxins	NA	
210.	Pentachlorodibenzofurans	NA	
211.	Tetrachlorodibenzo-p-dioxins	NA	
212.	Tetrachlorodibenzofurans	NA	
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	NA	

ND = Not detected.

NA = Not analyzed.

X = Believed to be present based on engineering analysis of waste generating process.

Y = Believed to be present based on detection in treated residuals.

[a] Where concentrations are shown, units are mg/kg.

7. CALCULATION OF BDAT TREATMENT STANDARDS

In this section, EPA presents its determination of treatment standards using the performance data shown in Section 4 and again presented in Section 5 as part of the Agency's determination of substantial treatment.

As discussed in Section 1, EPA's methodology requires the Agency to first delete any performance data that do not represent a well-designed and well-operated treatment system. Additionally, all data must be adjusted for analytical recoveries. EPA previously performed this analysis in Section 5; as shown, EPA found 30 treated data points that represent treatment of F006 wastes using a well-designed and well-operated treatment system. (See Appendix D, Table D-1, for EPA's rationale for deleting data on F006.) These 30 treated data points are shown in Table 7-1.

Using the accuracy-corrected data, EPA developed treatment standards by averaging the performance data for each constituent and then multiplying the average value by a variability factor that accounts for variations in technology performance, waste characteristics, and laboratory analysis. This procedure is consistent with the Agency's methodology as detailed in Section 1.

Table 7-1 shows the calculations for the five metals regulated for F006 nonwastewaters. These standards represent instantaneous maximum concentrations that must be achieved as a prerequisite for land disposal. The concentrations are in mg/l (parts per million on a weight-per-volume basis) and represent values for the TCLP leachate.

Table 7 1 Regulated Constituents and Calculated Treatment Standards for F006

	Cadmium	Chromium	Lead	Nickel	Silver
	0.01	0.45	0.39	0.05	0.06
	0.06	0.09	0.39	0.03	0.05
	0.01	0.44	0.41	0.27	0.06
	0.01	0.89	0.40	0.02	0.06
	0.01	1.41	0.29	0.04	
	0.01			<0.06	
	0.01			0.11	
				0.04	
				0.02	
Average	0.018	0.66	0.37	0.072	0.056
Number of samples	7	5	5	9	4
Variability factor	3.72	7.94	1.37	4.47	1.29
Treatment standard	0.066	5.2	0.51	0.32	0.072

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Versar personnel involved in the preparation of this document included Mr. Jerome Strauss, Program Manager; Ms. Rajani Joglekar, Engineering Team Leader; Mr. David Pepson, Senior Technical Reviewer; Ms. Justine Alchowiak, Quality Assurance Officer; Mr. James Morgan and Ms. Olenna Truskett, Technical Reviewers; Ms. Juliet Crumrine, Technical Editor; and the Versar secretarial staff, Ms. Linda Gardiner and Ms. Mary Burton.

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APPENDIX A

STATISTICAL METHODS

A.1 F Value Determination for ANOVA Test

As noted in Section 1.2, EPA is using the statistical method known as analysis of variance (ANOVA) to determine the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets.

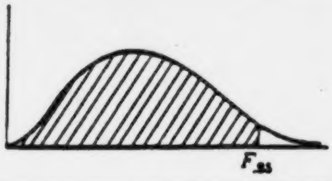
If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long-term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), the "best" technology would be the technology that achieves the best level of performance, i.e., the technology with the lowest mean value.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Table A-1

95th PERCENTILE VALUES FOR THE F DISTRIBUTION

n_1 = degrees of freedom for numerator
n_2 = degrees of freedom for denominator
(shaded area = .95)



n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.46	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2{}_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

MSB = SSB/(k-1) and
MSW = SSW/(N-k).

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F value
Between	k-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case in which one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	[ln(effluent)]^2	Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	[ln(effluent)]^2
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-	-	12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	-
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
	1.15	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 1 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$n_1 = 10,\ n_2 = 5,\ N = 15,\ k = 2,\ T_1 = 23.18,\ T_2 = 12.46,\ T = 35.64,\ T^2 = 1270.21$

$T_1^2 = 537.31 \quad T_2^2 = 155.25$

$$SSB = \left(\frac{537.31}{10} + \frac{155.25}{5}\right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left(\frac{537.31}{10} + \frac{155.25}{5}\right) = 0.77$$

$MSB = 0.10/1 = 0.10$

$MSW = 0.77/13 = 0.06$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2
Trichloroethylene

Steam stripping				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.44	19.71				
160.00	10.00	2.30	5.29				
Sum:							
	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	-
Variability Factor:							
-	3.70	-	-	-	1.53	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 2 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 10,\ N_2 = 7,\ N = 17,\ k = 2,\ T_1 = 26.14,\ T_2 = 16.59,\ T = 42.73,\ T^2 = 1825.85,\ T_1^2 = 683.30,$

$T_2^2 = 27\quad 3$

$$SSB = \left(\frac{683.30}{10} + \frac{275.23}{7}\right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left(\frac{683.30}{10} + \frac{275.23}{7}\right) = 4.79$$

$MSB = 0.25/1 = 0.25$

$MSW = 4.79/15 = 0.32$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$\ln[(\text{effluent})]^2$
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.20	-	-	38.90	228.34
Sample Size:							
4	4	4	-	7	7	7	-
Mean:							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation:							
1835.4	32.24	.95		16311.86	379.04	1.42	-
Variability Factor:							
-	7.00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^{\,2}}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$MSB = SSB/(k-1)$

$MSW = SSW/(N-k)$

$F = MSB/MSW$

Example 3 (Continued)

where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 4$, $N_2 = 7$, $N = 11$, $k = 2$, $T_1 = 14.49$, $T_2 = 38.90$, $T = 53.39$, $T^2 = 2850.49$, $T_1^2 = 209.96$

$T_2^2 = 1513.21$

$$SSB = \left[\frac{209.96}{4} + \frac{1513.21}{7}\right] - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) = 14.88$$

$MSB = 9.52/1 = 9.52$

$MSW = 14.88/9 = 1.65$

$F = 9.52/1.65 = 5.77$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous). Activated sludge followed by carbon adsorption is "best" in this example because the mean of the long-term performance value, i.e., the effluent concentration, is lower.

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2 Variability Factor

$$VF = \frac{C_{99}}{Mean}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data;

C_{99} = estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = \mathrm{Exp}(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data; and

Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and, hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data show that the treatment residual concentrations are distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean), as follows:

$$VF = \frac{C_{99}}{Mean}. \qquad (1)$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally distributed concentrations can be found in most mathematical statistics texts (see, for example, Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = Exp\ (\mu + 2.33\sigma) \qquad (2)$$
$$Mean = Exp\ (\mu + 0.5\sigma^2). \qquad (3)$$

By substituting (2) and (3) in (1), the variability factor can then be expressed in terms of σ as follows:

$$VF = Exp\ (2.33\ \sigma - 0.5\sigma^2). \qquad (4)$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a variability factor.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.

- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).

- Assumption 3: The standard deviation (σ) of the normal distribution is approximated by:

$$\sigma = [\ln(UL) - \ln(LL)] / [(2)(2.33)] = [\ln(UL/LL)] / 4.66. \qquad (5)$$

(Note that when LL = (0.1)(UL) as in Assumption 1, then $\sigma = (\ln 10) / 4.66 = 0.494$.)

Substitution of the σ value from equation (5) into equation (4) yields the variability factor, VF, as shown:

$$VF = 2.8. \qquad (6)$$

APPENDIX B

ANALYTICAL QA/QC

This appendix presents quality assurance/quality control (QA/QC) information for the available performance data presented in Section 4 and identifies the methods and procedures used for analyzing the constituents to be regulated. The QA/QC information includes matrix spike recovery data that are used for adjusting the analytical results for accuracy. The adjusted analytical results (referred to as accuracy-corrected concentrations), in general, are used for comparing the performance of one technology to that of another and for calculating treatment standards for those constituents to be regulated.

B.1 Accuracy Correction

The accuracy-corrected concentration for a constituent in a matrix is the analytical result multiplied by the correction factor (the reciprocal of the recovery fraction,* i.e., the correction factor is 100 divided by the percent recovery). For example, if Compound A is measured at 2.55 mg/l and the percent recovery is 85 percent, the accuracy-corrected concentration is 3.00 mg/l:

$$\underset{\text{(analytical result)}}{2.55 \text{ mg/l}} \quad \times \quad \underset{\text{(correction factor)}}{1/0.85} \quad = \quad \underset{\text{(accuracy-corrected concentration)}}{3.00 \text{ mg/l}}$$

---

*The recovery fraction is the ratio of (1) the measured amount of constituent in a spiked aliquot minus the measured amount of constituent in the original unspiked aliquot to (2) the known amount of constituent added to spike the original aliquot (refer to the Generic Quality Assurance Project Plan for Land Disposal Restriction Program ("BDAT")).

The appropriate recovery values are selected according to the procedures specified in Section 1.2.6.

Table B-1 presents matrix spike recovery data for the stabilized F006 waste residuals. Using these analytical recovery values, all the data points were corrected for accuracy.

B.2 Methods and Procedures Employed to Generate the Data Used in Calculating Treatment Standards

Table B-2 lists the methods used for analyzing the constituents to be regulated in F006 waste. Most of these methods are specified in SW-846 (USEPA 1986a). For some analyses, SW-846 methods allow alternatives or equivalent procedures and/or equipment to be used. The Agency plans to use these methods and procedures to enforce the treatment standards for F006 waste.

Table B-1 Matrix Spike Recoveries for Treated Waste

Constituent	Original amount found (ppm)	Duplicate (ppm)	% Error	Actual spike	% Recovery	Accuracy-correction factor
Arsenic	0.101[a]	0.01	0.0	0.086	94.5	1.06
	0.01[b]	0.01	0.0	0.068	104	0.96
Barium	0.3737[a]	0.3326	5.82	4.9474	91.9	1.09
	0.2765[b]	0.222	10.9	5.1462	97.9	1.02
Cadmium	0.0075[a]	0.0069	4.17	4.9010	97.9	1.02
	2.9034[b]	0.7555	58.7	6.5448	94.3	1.06
Chromium	0.3494[a]	0.4226	9.48	4.6780	85.8	1.17
	0.2213[b]	0.2653	9.0	4.5709	86.6	1.15
Copper	0.2247[a]	0.2211	0.81	4.8494	92.5	1.08
	0.1526[b]	0.1462	2.14	4.9981	97.0	1.03
Lead	0.3226[a]	0.3091	2.14	4.9619	92.9	1.08
	0.2142[b]	0.2287	3.27	4.6930	89.4	1.12
Mercury	0.001[a]	0.001	0.0	0.0034	92	1.09
	0.001[b]	0.001	0.0	0.0045	110	0.91
Nickel	0.028[a]	0.0264	6.87	4.5400	90.3	1.11
	0.4742[b]	0.0859	69.3	4.6093	86.6	1.15
Selenium[c]	0.101[a]	0.12	8.6	0.175	86	1.16
	0.043[b]	0.053	10.4	0.095	66[d]	0.96
Silver[c]	0.0437[a]	0.0399	4.55	4.2837	84.8	1.18
	0.0344[b]	0.0411	8.87	0.081	0.87[d]	114.9
Zinc	0.0133[a]	0.0238	28.3	5.0910	101.4	0.99
	27.202[b]	3.65	76.3	19.818	87.8	1.14

[a] At a mix ratio of 0.5.

[b] At a mix ratio of 0.2.

[c] For a mix ratio of 0.2, correction factors of 1.16 and 1.18 were used when correcting for selenium and silver concentrations, respectively.

[d] This value is not considered in the calculation for the accuracy-correction factor.

Reference: Memo to R. Turner, USEPA/HWERL from Jesse R. Conner, Chemical Waste Management, dated January 20, 1988.

Table B-2 Analytical Methods for Regulated Constituents

Analysis/methods	Method	Reference
Volatile Organics		
Purge-and-trap	5030	1
Gas chromatography/mass spectrometry for volatile organics	8240	1
Semivolatile Organics		
Continuous liquid-liquid extraction (treated waste)	3520	1
Soxhlet extraction (untreated waste)	3540	1
Gas chromatography/mass spectrometry for semivolatile organics: Capillary Column Technique	8270	1
Metals		
Acid digestion		
• Aqueous samples and extracts to be analyzed by inductively coupled plasma (ICP) atomic emission spectroscopy	3010	1
• Aqueous samples and standards to be analyzed by furnace atomic absorption (AA) spectroscopy	3020	1
• Sediments, sludges, and soils	3050	1
Lead (AA, furnace technique)	7421	1
Zinc (ICP)	6010	1
Toxicity Characteristic Leaching Procedure (TCLP)	51 FR 40643	2

References:

1. USEPA 1986a.
2. USEPA 1986b.

APPENDIX C

METHOD OF MEASUREMENT FOR THERMAL CONDUCTIVITY

The comparative method of measuring thermal conductivity has been proposed as an ASTM test method under the name "Guarded, Comparative, Longitudinal Heat Flow Technique." A thermal heat flow circuit is used that is the analog of an electrical circuit with resistances in series. A reference material is chosen to have a thermal conductivity close to that estimated for the sample. Reference standards (also known as heat meters) having the same cross-sectional dimensions as the sample are placed above and below the sample. An upper heater, a lower heater, and a heat sink are added to the "stack" to complete the heat flow circuit. See Figure C-1.

The temperature gradients (analogous to potential differences) along the stack are measured with type K (chromel/alumel) thermocouples placed at known separations. The thermocouples are placed into holes or grooves in the references and also in the sample whenever the sample is thick enough to accommodate them.

For molten samples, pastes, greases, and other materials that must be contained, the material is placed into a cell consisting of a top and bottom of Pyrex 7740 and a containment ring of marinite. The sample is 2 inches in diameter and 0.5 inch thick. Thermocouples are not placed into the sample; rather, the temperatures measured in the Pyrex are extrapolated to give the temperature at the top and bottom surfaces of the sample material. The Pyrex disks also serve as the thermal conductivity reference material.

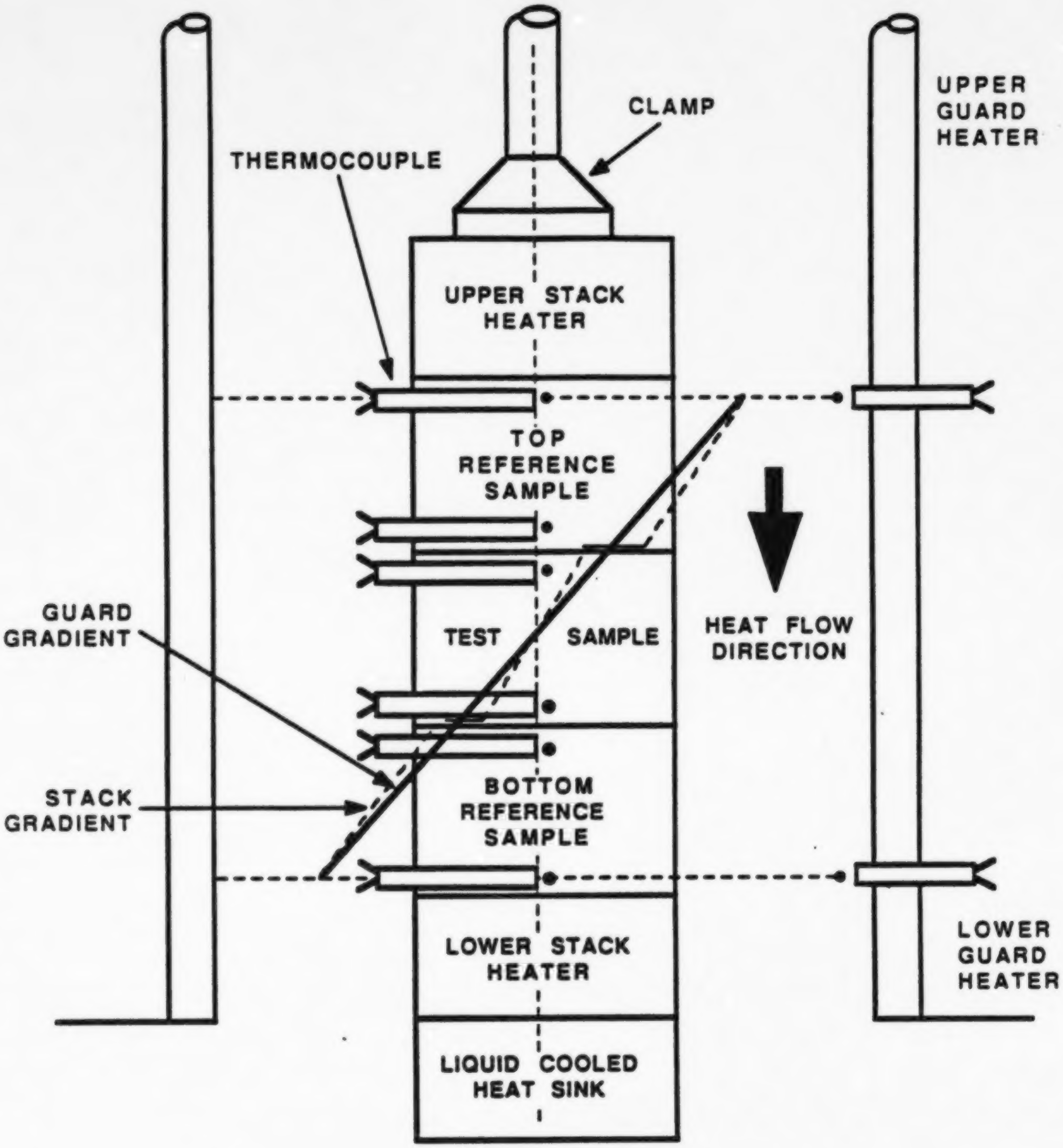

CLAMP
UPPER GUARD HEATER
THERMOCOUPLE
UPPER STACK HEATER
TOP REFERENCE SAMPLE
TEST SAMPLE
HEAT FLOW DIRECTION
GUARD GRADIENT
STACK GRADIENT
BOTTOM REFERENCE SAMPLE
LOWER STACK HEATER
LOWER GUARD HEATER
LIQUID COOLED HEAT SINK

FIGURE C-1 SCHEMATIC DIAGRAM OF THE COMPARATIVE METHOD

The stack is clamped with a reproducible load to ensure intimate contact between the components. To produce a linear flow of heat down the stack and reduce the amount of heat that flows radially, a guard tube is placed around the stack, and the intervening space is filled with insulating grains or powder. The temperature gradient in the guard is matched to that in the stack to further reduce radial heat flow.

The comparative method is a steady-state method of measuring thermal conductivity. When equilibrium is reached, the heat flux (analogous to current flow) down the stack can be determined from the references. The heat into the sample is given by

$$Q_{in} = \lambda_{top} (dT/dx)_{top}$$

and the heat out of the sample is given by

$$Q_{out} = \lambda_{bottom} (dT/dx)_{bottom}$$

where

λ = thermal conductivity

dT/dx = temperature gradient

and top refers to the upper reference, while bottom refers to the lower reference. If the heat were confined to flow down the stack, then Q_{in} and Q_{out} would be equal. If Q_{in} and Q_{out} are in reasonable agreement, the average heat flow is calculated from

$$Q = (Q_{in} + Q_{out})/2.$$

The sample thermal conductivity is then found from

$$\lambda_{sample} = Q/(dT/dx)_{sample}.$$

APPENDIX D

DELETION OF PERFORMANCE DATA FOR F006 WASTES

Table D-1 shows the deletion of data points from F006 stabilization performance data.

Table D-1 Deletion of Stabilization Performance Data for F006 Wastes

Source	Mix ratio[a]	Metal concentrations (ppm)										
		Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown												
Unstabilized												
As received		-	36.4	1.3	1270	40.2	35.5	-	435	-	2.3	1560
TCLP		<0.01	0.08	0.01	0.34	0.15	0.26	<0.001	0.71	<0.01	0.01	0.16
Stabilized												
TCLP	0.2	<0.01[b]	0.122[c]	0.011[d]	0.587[c]	0.206[c]	0.336[c]	<0.001[b]	0.046	0.058[b]	0.035[d]	0.034
Autopart manufacturing												
Unstabilized												
As received		-	21.6	31.3	755	7030	409	-	989	-	6.62	4020
TCLP		<0.01	0.32	2.21	0.76	368	10.7	<0.001	22.7	<0.01	0.14	219
Stabilized												
TCLP	0.2	<0.01[e]	0.51[e]	0.53[e]	0.46[e]	5.56[e]	0.448[e]	<0.001[e]	1.73[e]	0.058[e]	0.035[e]	42.1[e]
TCLP	0.5	<0.01[b]	0.458[c]	0.010	0.454	0.27	0.389	<0.001[b]	0.033	0.118[b]	0.059	0.010
Aircraft overhauling												
Unstabilized												
As received		-	85.5	67.3	716	693	25.7	-	259	-	39	631
TCLP		0.01	1.41	1.13	0.43	1.33	0.26	<0.001	1.1	<0.01	0.02	5.41
Stabilized												
TCLP	0.2	<0.01[b]	0.337	0.064	0.092	1.69[c]	0.336[c]	<0.001[b]	0.265	0.067[b]	0.236[c]	0.057
TCLP	0.5	<0.01[e]	0.338[e]	0.020[e]	0.234[e]	1.99[e]	0.443[e]	<0.001[e]	0.167[e]	0.128[e]	0.059[e]	0.030[e]
Aerospace manufacturing (F006 & F007 mixture)[f]												
Unstabilized												
As received		-	0.74	1.69	12.9	18.6	11.4	-	234	-	6.26	8.86
TCLP		<0.01	0.83	0.66	7.58	4.12	6.86	0.003	158	<0.01	1.64	2.28
Stabilized												
TCLP	1.0	<0.01	0.530	<0.01	0.46	0.237	0.274	<0.001	5.00	0.16	0.106	0.057
TCLP	1.5	<0.01	1.29	0.010	0.398	0.205	0.389	<0.001	2.74	0.232	0.177	0.030

Table D-1 (Continued)

Source	Mix ratio[a]	Metal concentrations (ppm)										
		Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Zinc plating												
Unstabilized												
As received		-	17.2	1.30	110	1510	88.5		37	-	9.05	90200
TCLP		-	0.84	0.22	0.18	4.6	0.45	<0.001	0.52	-	0.16	2030
Stabilized												
TCLP	0.2	<0.01[e]	0.204[e]	0.011[e]	0.263[e]	0.309[e]	0.336[e]	<0.001[e]	0.115[e]	0.077[e]	0.035[e]	06.5[e]
TCLP	0.5	<0.01[b]	0.251	0.010	0.351[c]	0.206	0.367[g]	<0.001[b]	0.022	0.162[b]	0.047	0.004
Unknown												
Unstabilized												
As received		-	14.3	720	12200	160	52	-	701	-	5.28	35900
TCLP		<0.01	0.38	23.6	25.3	1.14	0.45	<0.001	9.78	<0.01	0.08	867
Stabilized												
TCLP	0.2	<0.01[e]	0.316[e]	3.424[e]	0.288[e]	0.206[e]	0.269[e]	<0.001[e]	0.610[e]	0.034[e]	0.047[e]	3.88[e]
TCLP	0.5	<0.01[b]	0.207	0.010	0.44	0.313	0.389[g]	<0.001[b]	0.046	0.104[b]	0.071[g]	0.030
Small engine manufacturing												
Unstabilized												
As received		-	24.5	7.28	3100	1220	113	-	19400	-	4.08	27800
TCLP		<0.01	0.07	0.3	38.7	31.7	3.37	0.003	730	<0.01	0.12	1200
Stabilized												
TCLP	0.2	<0.01[e]	0.306[e]	0.021[e]	0.242[e]	0.216[e]	0.336[e]	<0.001[e]	18.9[e]	0.048[e]	0.035[e]	41.4[e]
TCLP	0.5	<0.01[b]	0.360[c]	0.010	0.889	0.206	0.389	<0.001[b]	0.055	0.128[b]	0.059	0.040
Circuit board manufacturing												
Unstabilized												
As received		-	12.6	5.39	42900	10600	156	-	13000	-	12.5	120
TCLP		<0.01	0.04	0.06	360	8.69	1.0	<0.001	152	<0.01	0.05	0.62
Stabilized												
TCLP	0.2	<0.01[e]	0.041[e]	0.011[e]	3.45[e]	0.412[e]	0.336[e]	<0.001[e]	0.46[e]	0.034[e]	0.035[e]	0.023[e]
TCLP	0.5	<0.01[b]	0.153[c]	0.010	1.416	0.454	0.410	<0.001[b]	0.111	0.031[b]	0.059[c]	0.020

Table D-1 (Continued)

Source	Mix ratio[a]	Metal concentrations (ppm)										
		Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Unknown												
Unstabilized												
As received		-	15.3	5.81	47.9	17600	169	-	23700	-	8.11	15700
TCLP		<0.01	0.53	0.18	0.04	483	4.22	<0.001	644	<0.01	0.31	650
Stabilized												
TCLP	0.2	<0.01[e]	0.326[e]	0.011[e]	0.115[e]	0.515[e]	0.347[e]	<0.001[e]	18.1[e]	0.067[e]	0.035[e]	5.18[e]
TCLP	0.5	<0.01[b]	0.294	0.010	0.234[c]	0.346	0.400	<0.001[b]	0.044	0.081[b]	0.059	0.020
Unknown												
Unstabilized												
As received		-	19.2	5.04	644	27400	24500	-	5730	-	19.1	322
TCLP		0.88	0.28	0.01	0.01	16.9	50.2	<0.001	16.1	<0.45	<0.01	1.29
Stabilized												
TCLP	0.2	<0.02[e]	0.194[e]	<0.01[e]	0.035[e]	3.28[e]	2.677[e]	<0.001[e]	1.25[e]	<0.01[e]	<0.01[e]	0.080[e]
TCLP	0.5	<0.02[b]	0.087	<0.010[d]	0.256[d]	0.497	0.291	<0.001[b]	0.022	<0.01[b]	<0.01[d]	<0.01

---

[a] Mix ratio = $\frac{\text{weight of reagent}}{\text{weight of waste}}$

[b] Data deleted because no untreated total composition or TCLP value is available to demonstrate treatment.

[c] Data deleted because treated TCLP value is greater than untreated TCLP value.

[d] Data deleted because untreated TCLP value is too low to show meaningful treatment.

[e] Data deleted because of less effective design and operation.

[f] Data deleted because untreated waste is a mixture of F006 and F007.

[g] Data deleted because reduction in leachability is attributed to dilution rather than treatment.

Reference: Chemical Waste Management Report No. 87-117 (CWM 1987).